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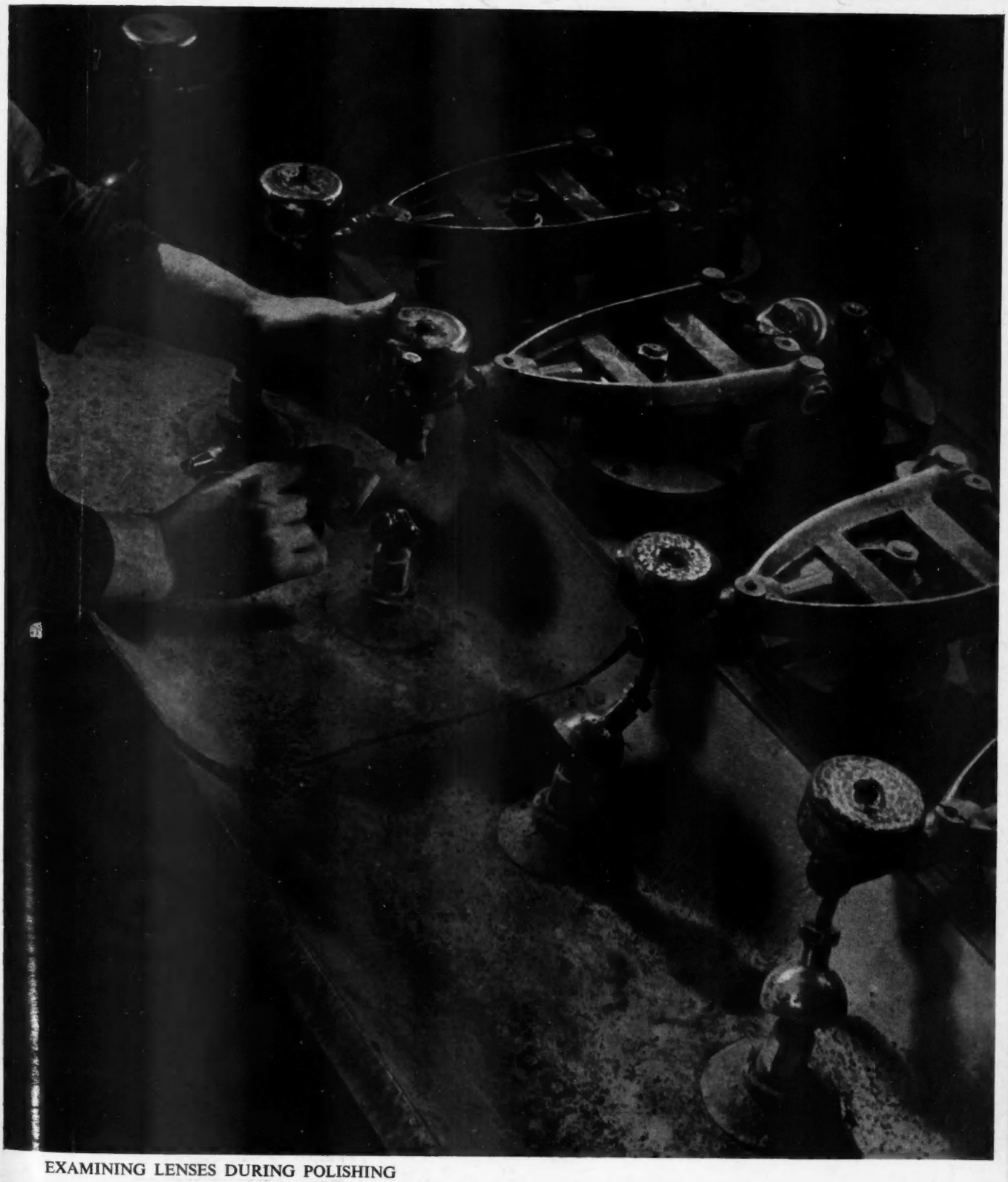

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ENGINEERING

An Illustrated Weekly Journal

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THE RAILWAY CONGRESS

FOR the 16th session of the International Railway Congress Association, which is being held in London this week and next, the United Kingdom Government (through the Ministry of Transport), the British Transport Commission, and a large number of railway and engineering firms up and down the country, are hosts to the distinguished representatives of overseas governments and railways who are taking part in the Congress. The arrangements that have been made to entertain and instruct the delegates compare favourably with the arrangements that were made for the two previous congresses at Rome in 1950 and Lucerne in 1947. In Switzerland and in Italy the visitors were privileged to see something of what those two delightful countries can show the tourist, and now in Great Britain similar opportunities are open to the delegates of 1954.

The railways of a country are so much a part of the social and industrial pattern, and are so closely related to its economic development, that it is hardly possible to appreciate the characteristics of the railways without first knowing something of the country itself. When the delegates return to their homes abroad, the impression they take with them of the establishments they have visited, and of British Railways and London Transport, will be founded on their impression of the people, the formal and informal social functions they attend, the towns and villages of Britain. These impressions will determine, to a large extent, the value that the delegates derive from the technical meetings of the Congress.

In 1947, when most European states were heavily engaged in post-war reconstruction, the dominant impression in Switzerland was of a splendid railway system, efficient, modern and fortunately undamaged. In 1950, Italian railway officers were rightly proud of the work they had done on a railway system which had suffered severely during the war. This year, undoubtedly, most of the delegates will be curious to observe at first hand the effect of unifying the railways under a single authority, responsible, through the Minister of Transport, to the Government. We will therefore regard the subject as *sub judice* and leave them to judge for themselves. As onlookers they may see more, favourable and unfavourable, than a native of this country is able to see.

The Congress derives its usefulness largely from its international composition (about 45 countries are represented at Church House, Westminster, where the Congress is being held). Several subjects for discussion are chosen well in advance of each Congress. The approach to each subject is then settled by compiling a number of questions designed to elicit significant information from all the railways taking part, and when the replies are received they are integrated and presented in a form suitable for discussion at the Congress. A vast amount of information is collected in this way, and is available for study apart from the necessarily condensed reports used at the technical meetings. It is fundamental information; so fundamental, in fact, that a railway officer reading the report of his country may feel that it is platitudinous and familiar knowledge. But he would be wrong if he were to value it lightly. To a railway officer from another country it will be unfamiliar, and he will want to know the reasons for the differences in practice. In finding out he cannot avoid stimulating discussion. The onlooker, again, often sees most of the game.

At least seven of the eleven questions to be discussed in London are engineering subjects. One deals with methods of improving the efficiency of steam locomotives, emphasising particularly the possibility of increasing the boiler pressure, pre-heating the feed water, the degree of superheating, types of grates, and feed-water treatment. Another examines the use and scope of radio communications in railway work (this subject has not previously been discussed at a Railway Congress). Two deal with electric traction, the first with "technical and economic investigation of the basic characteristics of electric traction systems now in use, with a view to deciding whether, and to what extent, there are relevant reasons for preferring one system to another." The subject is considered in relation to power supply, overhead-line and fixed track installations, motive-power units, and working and maintenance costs. The other electric-traction question is concerned with the protection of overhead lines, substations, locomotives and motor coaches against accidents of an electrical nature. For civil engineers there are two principal subjects under discussion. The first deals with the organisation of permanent way maintenance, and the second with the wear of rails on curves. The latter question, particularly, is one which is likely to produce much empirical but none the less useful information. The delegates will derive much from the technical meetings and they can be sure of a sincere welcome from their numerous hosts – Government, railway and industrial.

Weekly Survey

BANK RATE AT 3 PER CENT.

The decision last week to reduce bank rate to 3 per cent. came as a surprise. It had been expected that the recent heavy flow of funds to London, the strength of sterling and the downward trend of interest rates in the United States (which was in itself partly responsible for the movement of funds to London) would have persuaded the authorities to lower bank rate some weeks ago. When the inflow of funds and consequent reduction in the short-term lending rate in London did not bring an adjustment of the bank rate earlier this month it was assumed that no change was forthcoming. The prophets were found to be wrong only in their timing.

This adjustment to 3 per cent. is on the whole an orthodox reaction to the strength of the pound. There is, it is true, a certain value in the figure of 3 per cent. since psychological reactions to an upward adjustment by ½ per cent. would be less violent from 3 per cent. than from 3½ per cent., but so far as industry is concerned, the effects of a lower bank rate are bound to be slightly inflationary. This naturally raises the question whether the capital goods industries need any inflationary stimulant at the moment. Even if they do, is this the right kind of stimulant to apply? Bank rate can be a very flexible instrument from a financial point of view but from industry's point of view it is invariably a blunt weapon and its effects work themselves out with no regard to the requirements of any particular industry. Thus, if the fall of ½ per cent. makes it easier and cheaper for industry to get both long-term and short-term credit, the advantage will accrue to the whole industrial structure and no particular section of it will automatically improve its position compared with others.

The engineering industry could benefit from any increase in capital investment that cheaper money might bring about, or if it needed more and cheaper capital to compete overseas. Although engineering companies' order books were far from full in many cases early this spring there are signs that this phase of stagnation is passing and there is no general slack of resources to be taken up. Furthermore, the trend of bank advances in the last few months shows that the banks have not been unwilling to advance working capital. It is early yet to say what the effect of the change in bank rate will be on the engineering industry but it might well turn out to be a mildly adverse factor, because the industry has recently received an impetus from the investment allowance in the Budget and there are clear signs that the symptoms of recession apparent in the earlier part of the year in order books are passing even before the effects of the investment allowance have had a chance to work themselves out. There might be, then, slight general inflationary pressure which will bring the capital goods industries into competition with consumer goods industries for resources of men and machines in an economy which is already fully stretched.

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QUALITY CONCRETE

It is important that concrete of adequate strength and durability should be used in constructional work, and also that every effort should be made to improve this and every other engineering material in any way that is possible. That nearly 1,500 engineers, many of them from the Continent, should have applied to attend a symposium on mix design and quality control of concrete is a sign that most branches of the civil engineering and building industries are conscious of the need for good concrete – perhaps the principal construction material in use to-day.

The symposium, held in London last week, was organised by the Cement and Concrete Association in conjunction with interested bodies. The co-operation of the Building Research Station and the Road Research Laboratory of the Department of Scientific and Industrial Research was obtained, the introductory address being given by Dr. W. H. Glanville, C.B., director of the Road Research Laboratory, and several of the papers by members of the staff of the Department. In all, 22 papers were presented in six working sessions, the range of topics considered covering the selection of materials, the types of concrete suitable for different purposes, the methods to be adopted for mixing the required type of concrete as well as for measuring its strength and other properties, and, finally, a paper considering the principles of specifying and standardising concrete practice generally.

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PROSPERITY IN WESTERN EUROPE

The May meetings of the Organisation for European Economic Co-operation (O.E.E.C.) revealed substantial economic progress by Western Europe. Industrial production rose rapidly during the past six months, and in the first quarter of this year was about 7 per cent. higher than a year ago. The improvement, which began in November, shows no sign so far of being affected by the recession in the United States; on the contrary, European trade had a steadying influence on the world economy. The gold and dollar reserves of Western Europe rose by 2·2 billion dols. in 1953. Higher demand by European countries at a time when U.S. purchases were falling gave commodity prices the required support to keep them steady. This enabled primary producing countries to increase their imports of European products. The fall in European exports to the United States, which matched the recession there, was more than offset by U.S. expenditure in Western Europe which, in 1953, amounted to 2¼ billion dols. This is likely to be even greater during the current year, and there is therefore every hope of a further improvement in the gold and dollar reserves, provided European exports to North America can be maintained.

Detailed and interesting reports on convertibility and on the liberalisation of inter-European trade showed that some progress had been made towards both objectives, although the performance of some countries was much better than others. It is clear that the countries which have achieved the liberalisation of more than 90 per cent. of their inter-European trade – Germany, Italy, Switzerland, Sweden, Portugal and the Netherlands – feel themselves to be in a much stronger position to withstand competition both in their own countries and in other European markets. The ability to compete is without doubt a prerequisite of the removal of import restrictions and the freeing of currencies. The United Kingdom's performance was a little better than average, and France's by far the worst. At April 1, 1954, 80 per cent. and 18 per cent. respectively of these countries' imports were free from quota regulations.

The O.E.E.C's economic committee consider that Western Europe has reached a period of relative stability and freedom from balance-of-payment difficulties, and that these conditions should make possible further economic expansion. They point out that if defence expenditures of the member countries are stabilised or reduced, more of the countries' income will be available for capital investment, which has been neglected in most countries. There is no doubt that the better prospects make further progress with liberalisation of trade and towards the freer convertibility of currencies likely during 1954. This should be very much to the advantage of British manufacturers of engineering products, provided they are able to compete with the leading trading nations in Europe, with Germany and the United States.

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ACCOUNTANCY SERVICE FOR WORKS MANAGEMENT

A paper on "The Accountancy Service to Works Management" was presented by Mr. C. E. Power on May 7, at a meeting of the Institution of Mechanical Engineers. "Without an efficient accountancy service," said Mr. Power, "it is difficult to visualise how management at all levels can have sufficient control to limit the possibility of events running ahead of it."

He considered that assistance was of three kinds, covering cost control, budgetary control and standard costing. Under the first, the cost and financial evaluation of management's objectives must be assessed and targets set. Further, the cost and financial results must be consistently ascertained so that actual performance can be measured against these targets. Budgetary control was necessary for the planning and control, of capital operations, the desired profit and the adequacy of working capital and cash resources. Of these, works management was primarily interested in expenditure of manufacturing operations. The preparation of cost budgets required an assessment of cost, and standard costing throughout an organisation was essential in this connection. There were other important subjects, such as wages policy and stock control, where the accountant could be of great help both to the board of directors and to works management. "The relation between works management and the cost accountant is that although the activities and responsibilities of the cost accountancy function relate to all aspects of cost, whether production, selling or administrative costs, inevitably the greater part of its work is concerned with providing all levels of works management with cost and ancillary information. It must always be an intermediary function in view of the separate needs of works and commercial departments, and of general management, and, with a unified accountancy service, would not be directly controlled by works management. Co-operation and mutual understanding must, therefore, be the basic relation. This is particularly essential between the cost accountant and his staff and works supervision, since by far the majority of basic recorded data originate on the floor of the works, and without co-operation and understanding at this level, cost information produced may be comparatively worthless or even thoroughly misleading."

The paper then examined the way in which cost control must be adapted to the characteristics of the organisation concerned. The basic data were usually available for setting up such a form of control but sometimes there was difficulty with production times. This problem had been overcome in some cases by the time study and rate-fixing data already available for incentive schemes, etc. Cost control information must then be collected in accordance with either a standard control or a budgetary control technique. Having achieved a satisfactory method of estimating costs and recording actual costs it was necessary to analyse variances from estimated costs in order to make cost control effective. These variances might be segregated

to indicate variances due to price, performance or changed methods or specifications. It was in achieving the right amount of detail in setting out the breakdowns that the cost accountant could offer outstanding help to works management. That service was best which offered information in a summarised form and the requisite amount of detail as well. Here, he claimed, is a valuable tool in a planned approach to cost reduction.

* * *

B.O.A.C. MAKE A BIG PROFIT

Sir Miles Thomas's review of the performance of British Overseas Airways Corporation during the year ended March contained excellent financial news, but dwelt on the disasters experienced with the Comet I, and their impact on the Corporation's schedules. In spite of the grounding of the Comet fleet, the results are much the best recorded so far. After paying interest on capital, £933,050, from operating profits, the Corporation was left with a surplus of slightly over £1 million, compared with a deficit of £838,664 in the previous year. The better results appear to be due to a reduction in operating costs from 40·1*d.* to 39·6*d.* per capacity ton-mile, although there was a 5 per cent. increase (about £1½ million) in the total revenue, implying more profitable loads. Revenue per load ton-mile went up from 60·7*d.* to 62·1*d.* But the load factor – the proportion of aircraft space filled with paying passengers – remained at the same level as last year, 64·5 per cent. Even a small improvement in this would obviously greatly increase the Corporation's profits.

The grounding of the seven Comets, which were equal in productive capacity to several more aircraft of conventional type, has forced the Corporation to reduce its aircraft commitments. This has been done by withdrawing the service to South America; only, it is hoped, as a temporary measure. The Argonaut aircraft thus released have been switched to African and Eastern routes to replace the Comets. Sir Miles Thomas is confident that the Comets will fly again, and very conscious of their importance to B.O.A.C.

The financial future of the Corporation must, to a very large extent, depend on the use of low-cost aircraft, and until the Comets are restored to service or the Britannias are available the Corporation may be unable to maintain its rate of profit, unless a decision is made to buy stop-gap aircraft from the United States.

* * *

INTERNATIONAL RESEARCH

Among the technical organisations established by Unesco on an international plane is the European Council for Nuclear Research, the aim of which is to enable the scientists of European countries engaged in this most significant field of study to "work together for the common good."

In Europe the common good depends essentially on collaboration, and in particular does this apply to branches of activity requiring expensive equipment. In nuclear research, for example, the economic factor has tended seriously to hinder progress, since for the proper study of the atomic nucleus costly laboratory installations are necessary, and few scientific institutions, and in fact few European states, can afford to provide them. The result has been an increasing temptation for talented physicists to emigrate to the United States.

This grave state of affairs may be partly overcome and frustration removed by the construction in Switzerland of a new international laboratory, to be built, on behalf of the Council for Nuclear Research, near Meyrin, close to the French frontier. The laboratory will house an extensive range of scientific plant, including a proton synchrotron designed to produce a proton beam of 25 GeV and a version of the more classical synchro-cyclotron with a proton beam of 600 MeV. Nearby hydro-electric power stations on the Rhône will supply the necessary electric power for the installations. The laboratory will probably be staffed to a considerable extent by transient personnel, who will, in consequence of their experience, be better able to serve their own institutions on their return.

The laboratory is only one aspect of the Council's work, which will be of a purely scientific and fundamental character, having no concern with military requirements. The results of all theoretical and experimental studies will be published. An account of the Council's activities and origins is given in a booklet entitled *European Co-operation in Nuclear Research* (H.M. Stationery Office, price 2*s.*).

* * *

GAS GRID FOR SUSSEX

The new gas plant at Portslade, Sussex, which is described in this issue, was inaugurated on May 3. The Duke of Norfolk opened the gates of the £3 million plant, of which two-thirds have been completed and which will supply about 17½ million cubic feet of gas a day when it is fully working. Supply mains will radiate to points as far as Littlehampton and Arundel, Petworth and Billingshurst, Haywards Heath, Uckfield and Seaford. The first two have been supplied from Portslade since 1938 and local plant at the others will be closed down in due course. It is expected in this way to produce gas for the whole area under more efficient and more economical conditions than at present. The existing horizontal retort plant at Portslade will be closed down as soon as possible, thereby reducing the local atmospheric pollution.

At the luncheon following the opening, Mr. W. K. Hutchison, C.B.E., said that this type of vertical-retort plant was probably the most efficient for a centralised station. Its position enabled sea-borne coal to be utilised – still the cheapest form available – with only a 30-hour journey from Yorkshire.

* * *

Letters to the Editor

HIGH-TEMPERATURE STEAM PIPES

Properties of Steel and Basis of Design

SIR, In commenting on my article in ENGINEERING of April 9 (page 457), which drew attention to the absence of a British Standard or Code of Practice applicable to the piping systems of the 1,000 deg. F. and 1,050 deg. F. stations now being built in Britain, Dr. J. S. Blair submits, on page 583 of your issue of May 7, that a British Standard does not purport to guide the designer of high-temperature stations but merely to correlate existing good practice, and he indicates that conditions for the high temperatures will be laid down "later."

This state of affairs forces numerous pipe makers, consultants, generation authorities and insurance companies to conduct their own researches concerning the appropriate design basis for new steam conditions. Effort would be saved and more consistent results obtained were we to follow the American example of delegating this task to a single committee of specialists who publish their recommendations *before* the time a new steam condition is introduced, and bring their recommendations up to date very quickly when new test data become available.

Dr. Blair draws attention to the measure of agreement between my article and an article by himself published in ENGINEERING of October 30, 1953 (page 549). I particularly welcome our agreement on the advantage of the rupture-stress design basis over the creep-strain design basis for non-precision components such as steam pipes, and also on the merits of the "thin-wall" formula for high-temperature conditions.

I cannot agree, however, with Dr. Blair's suggestion that the use of all pipe steels having a low value of the minimum creep ductility, x_f, should be avoided, particularly as Dr. Blair appears to regard $x_f = 9$ per cent., the value for molybdenum-vanadium steel (Glen, 1948) as low. According to this suggestion a large proportion of the steels now in use for high-temperature pipes would no longer be acceptable; namely, for example, stabilised austenitic steels with $x_f = 2$ per cent. to 3 per cent. (Kirkby and Sykes, 1951), carbon-molybdenum steels, $x_f = 4$ per cent. (Tapsell and Ridley, 1945), etc. It is more reasonable to compensate for low creep ductility and other shortcomings of a steel by the adoption of a higher rupture safety factor. The theoretical basis for this method of compensation is outlined in Appendix II to my article.

Dr. Blair's suggestion that 975 deg. F. should be adopted as a dividing line between the use of "cold-design" and "hot-design" formulæ does not seem a workable solution for a piping specification. The true transition temperature between the cold-design criterion (which bears a relation to the ultimate tensile stress) and the hot-design criterion (based on long-term rupture stresses) takes place at widely different temperatures for different steels, and is also influenced by the pressure/stress ratio. It can be specified conveniently in the manner illustrated by Table IV in my article.

Yours faithfully,
P. MARGEN.

12, Caxton Street,
London, S.W.1.
May 13, 1954.

* * *

DEARER COKE

SIR, In your issue of May 7, on page 578, you credit this Council with the statement that the price of coke would be increased by an average of about 5*s.* 8*d.* per ton. This amount referred only to the average increase in the cost of coking coal. The price increases in coke authorised by the Ministry of Fuel and Power since your issue of May 7 was published, are for substantially larger amounts – as in fact this Council feared would be the case.

Yours faithfully,
KENNETH MARSHALL,
Director.

The Joint Iron Council,
14 Pall Mall,
London, S.W.1.
May 10, 1954.

[Our statement was based on the following sentence which occurs in the *C.F.A. General Bulletin*, No. 85 for May, 1954, issued by the Council of Iron foundry Associations, the ironfounding constituent of the Joint Iron Council, and also of Crusader House, 14 Pall Mall, London, S.W.1. "The total extra cost of coal used in carbonisation in the coke ovens of the country will be about £5 million or an average of 4*s.* per ton of coal carbonised. As about 30 cwt. of coal are used to produce a ton of coke, this means an average increase of about 5*s.* 8*d.* per ton of coke produced. . . ."—Ed. E.]

ENGINEERING DEVELOPMENTS IN CENTRAL AFRICA*

TWO MAJOR HYDRO-ELECTRIC SCHEMES

By Sir William Halcrow, M.I.C.E., M.I.MECH.E.

Central Africa may be taken as comprising three countries which have recently been brought under federation – Southern Rhodesia, Northern Rhodesia and Nyasaland. With great mineral wealth and agricultural opportunities, Central Africa affords scope for industrial expansion, the realisation of which will depend largely on improved communications and a plentiful supply of cheap power. While the existing hydro-electric power in the area is almost negligible, the potential which can be developed is vast. Two great projects have so far been closely investigated and may be expected to materialise in the not too far distant future. These are the Kariba Gorge Scheme on the Zambesi river and the Kafue scheme on the Kafue river, a tributary of the Zambesi.

LARGE CATCHMENT AREA

The Kariba scheme is situated in the Kariba Gorge on the Zambesi, about 225 miles downstream from Livingstone. Here the river enters a narrow gorge of some 16 miles in length through which it passes with only a slight fall. A high dam at any suitable point in this gorge would pond the water back over a great distance to form a vast lake. The catchment area above the gorge is some 300,000 square miles and the average flow in the river is about 37,000 cubic feet per second. It has, however, a large seasonal variation and while in the dry season it may fall to 7,000 cubic feet per second or less, in the floods it may rise to 300,000 cubic feet per second or even more, that is, over 40 times as much. The topography is such, however, that a large storage can be created whereby the flow of the river can be regulated. The proposal is to construct a dam across the gorge some 400 feet in height, to form a lake some 150 miles long. The storage in a top layer of less than forty feet will be sufficient to permit complete regulation of the river flow, the surplus water in the floods and in years of heavy rainfall being stored and released as required to give a constant discharge in the river.

During construction it is proposed to divert the water through four diversion tunnels each of 50 feet in diameter. The dam will be constructed in the dry between cofferdams. Two or more of these tunnels will subsequently be adapted as spillway tunnels for flood water, the surplus water being passed through high level automatic gates to a downtake shaft leading to the tunnel, the former low level intakes used for diversion being sealed off.

The regulated output capacity of the Kariba scheme is estimated at 1,000,000 kW at 70 per cent. load factor, equivalent to 700,000 kW of continuous power. The cost excluding the transmission system was estimated in December, 1950, at about £44 million. (Battersea Power Station with the extension at present in hand has a capacity of 500,000 kW or just half of that of Kariba.)

The dam would have to be constructed to its full height before any power could be generated, but the scheme could be developed in stages by installing the generating plant as required. An initial installation of 300,000 kW at 70 per cent. load factor would cost £30 million excluding transmission. The period of construction of this initial scheme would be about seven years.

The estimated cost of energy was 0·20d. per kWh from the initial scheme and 0·10*d.* from the full scheme. The cost of energy delivered at the receiving stations and including the cost of and loss in transmission was 0·34*d.* for the initial and 0·19*d.* for the full schemes. There has been a rise in costs of construction and plant since the estimates were prepared but even allowing for this, the Kariba scheme offers the possibility of a large supply of energy at extremely cheap rates, far below those obtainable from steam power.

HIGH HEAD AT KAFUE

The Kafue is a tributary of the Zambesi, which it joins at about 25 miles downstream of the Kariba gorge. The Kafue rises on the frontier of the Belgian Congo and running in a generally southerly direction joins the Lukanga, a large tributary emerging from a vast swamp. The river then turns, first in a westerly direction and then south to a gap in a ridge of hills, known as the Meshi Teshi gap. After passing through here, it meanders in an easterly direction across a great flood plain known as the Kafue Flats. This plain has a length of 200 miles and a width of about 150 miles, is extremely flat, and is subject to considerable flooding in wet years. Emerging from the Flats, the river is crossed by railway and road bridges and enters the Kafue Gorge. This is a narrow gorge through which the river passes in a series of falls and cascades to descend 1,900 ft. in the 16½ mile length. Leaving the gorge the river crosses some 25 miles of the Zambesi plain to join that river. It is the steep fall through the gorge that offers the opportunity of power development.

The layout of the power scheme is as follows: a dam about 100 ft. in height is to be built across the gorge at its upper end. From here a high-level tunnel leads to a point near the Keshya ravine on the right flank of the river. Here a vertical surge shaft is to be constructed and extended as a downtake shaft leading to a short low-level tunnel connecting to a power station in the ravine. The total length of tunnel from the dam to the power station is about 8½ miles and the head 950 ft. A second dam across the ravine forms a small forebay from which the water is taken through a second tunnel some five miles in length, similar to the first tunnel and leading to a second power station on the Kafue Gorge. The layout is so arranged that the heads at each power station, and consequently the plant, are the same.

The river which has wide seasonal and annual variations of flow undergoes considerable natural regulation in its passage across the Kafue Flats, but the flow at Kafue, though perennial, is still subject to considerable variation, and the site affords no opportunity for creating a large storage lake to regulate this. The 100-ft. dam creates a small storage which is valuable in tiding over low flows in the dry season thus giving a constant discharge considerably higher than determined by the minimum dry-weather flow.

The nearest storage site is at the Meshi Teshi gap. Investigations are being carried out as to the practicability of a storage dam here and the capacity of the reservoir that would be formed. But this is not the whole problem. It has to be ascertained how much of a regulated flow released at Meshi Teshi would reach the Kafue Gorge after its passage across the 200 miles of the Kafue Flats. The solution of this requires not only extensive survey but, what takes much longer, the collection and building up of hydrological data.

The scheme proposed, therefore is one based on the storage obtainable in the immediate vicinity of the Kafue Gorge, but it has been designed so as to be elastic and readily capable of extension if by provision of additional storage or otherwise, the available water can be increased. The scheme is estimated to give an initial output of 257,000 kW at 80 per cent. load factor equivalent to 205,000 kW of continuous power. The cost excluding transmission is estimated at £18 million. The cost of energy is estimated at 0·15*d.* per kilowatt-hour of energy sent and 0·26*d.* per kilowatt-hour of energy delivered at the receiving stations after allowing for the cost of and loss in transmission.

The Kariba and Kafue schemes should in no sense be considered as rival schemes but as complementary to each other. Both will undoubtedly be required in the not too distant future to meet the growing demands of Central Africa. Much benefit could be derived by interlinking the two schemes, to serve a joint grid. By doing so, the vast storage of Kariba could virtually be utilised to supplement the small storage of Kafue and so take fuller advantage of the high head of Kafue.

Much discussion has taken place on the relative merits of Kafue and Kariba schemes, but the only real issue that arises is which scheme should be constructed first. On purely economic considerations it would be advantageous to construct Kariba first for the following reasons. The Kariba Dam would have to be constructed to its full height before any power could be obtained and extensions would consist of additions of plant. The lesser output of Kafue would only meet the prospective load in the Rhodesias for a short time and then any addition must come from Kariba. As this involves the construction of Kariba Dam to full height, this incremental energy would become very costly. On the load curves forecast, it was found that within the limits of 400 and 1,000 MW at 70 per cent. load factor, construction of Kafue first would involve a large additional capital expenditure.

POWER DEMAND FROM COPPER BELT

On the other hand, 257 MW could be got from Kafue at a cost per unit less than from an initial development of the same size at Kariba, but considerably more than that from the full development of Kariba. Power supply could start in five years, and reach full service in 6½ years as against seven years for the initial Kariba scheme. The arguments in favour of constructing Kafue first were that the expanding demands of the Copper Belt necessitated a power supply earlier than could be obtained from Kariba and that it would be easier to raise the £30 million required for Kafue than the considerably larger amount for Kariba. The first argument has been somewhat weakened by the fact that the copper companies have meanwhile arranged for a temporary supply of power from the Belgian Congo.

These two great schemes do not by any means, however, exhaust the power potential of Central Africa. There are other sites of magnitude on the Zambesi and many smaller sites on its tributaries.

* Extracts from a paper read before the Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2, on Tuesday May 18, 1954.

PERSONAL

LORD ADAMS OF ENNERDALE, O.B.E., who has been a part-time member of the Northern (Northumberland and Cumberland) Division of the National Coal Board since 1950, has now relinquished this post on account of ill-health.

COMMANDER (E) L. J. F. HOWARD-MERCER, M.I.Mech.E., M.I.Mar.E., M.I.N.A., R.N. (Ret.), has been appointed assistant to Mr. J. T. MacLeod, managing director of H. Widdop & Co. Ltd., Keighley, Yorkshire, manufacturers of marine Diesel engines.

MR. C. F. BARNARD has been appointed joint managing director of Associated British Oil Engines (Marine), Ltd., with MR. J. JONES, who is also managing director of the National Gas and Oil Engine Co. Ltd. Mr. Barnard also retains his position of managing director of Mirrlees, Bickerton and Day, Ltd.

MR. C. E. DARLINGTON, vice-principal of Halesowen College, Birmingham, has been appointed principal of Gateshead Technical College, in succession to MR. J. S. ELLIOTT, who has been appointed principal of Rutherford College of Technology, Newcastle-upon-Tyne.

MR. G. R. MARSH, who has been a director of Wickman Ltd. for 14 years, has been appointed managing director.

MR. W. MURE, C.B.E., has relinquished his positions on the boards of the Wolverhampton Metal Co. Ltd., and its subsidiary company, James Bridge Copper Works Ltd.

MR. H. W. BOWEN, O.B.E., M.I.Mech.E., M.I.P.E., has been appointed technical director to H. J. Baldwin & Co. Ltd., engineers, Nottingham, and consulting engineer to the Baldwin group of companies.

MR. N. M. HOOD, general manager, Tyne Improvement Commission, Newcastle-upon-Tyne, since 1940, is retiring on account of ill-health.

MR. WILLIAM DODDS, secretary of the Mercantile Dry Dock Co. Ltd., Jarrow-on-Tyne, is to retire at the end of June and will be succeeded by MR. A. W. K. GREEN, who joined the firm in October, 1952, as assistant secretary.

MR. V. J. FAULKNER has been elected chairman and MR. C. H. ALSOP, vice-chairman, of the Publicity Committee of the British Electrical and Allied Manufacturers' Association, 36 and 38 Kingsway, London, W.C.2.

MR. R. J. FOSTER, D.F.C., A.F.C., has been appointed by the British Oxygen Co. Ltd., Bridgewater House, Cleveland-row, St. James's, London, S.W.1, to be their liaison officer for the aircraft industry, the Services and Government departments.

MR. R. C. PRICE, editor of *Motor Cycle and Export Trader*, has been appointed Press officer of the Villiers Engineering Co. Ltd., Marston-road, Wolverhampton.

MR. R. J. COLE, senior lecturer in mechanical engineering at Rutherford College of Technology, Newcastle-upon-Tyne, is to retire. He joined the staff of the College in 1919.

MR. J. R. RIX, director of the Austin Motor Co. Ltd., Longbridge, Birmingham, has retired and is ceasing all business activities for health reasons.

MR. S. A. ROBERTS, who became general manager to the B.S.A. Tools Group in 1953, has now been appointed to the boards of B.S.A. Tools Ltd., Leo. C. Steinle Ltd., and Cardiff Foundry & Engineering Co. (1947) Ltd.

MR. B. J. HAILL, works manager of the Hirwaun foam-rubber factory of the Dunlop Rubber Co., has been appointed, in addition, general works manager of the new factories at Brynmawr and Cwmavon, which the Dunlop company have just taken over from Enfield Cables Ltd. MR. J. H. LORD, a director of the Dunlop company, has been elected a director of the Dunlop Tire and Rubber Corporation, Buffalo, U.S.A.

MR. K. A. BALLARD has been appointed to represent Samuel Osborn & Co., Ltd., Clyde Steel Works, Sheffield, 3, in connection with the sale of steel castings. He will be attached to the company's London office at Donington House, Norfolk-street, W.C.2.

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BUSINESS CHANGES

THE BRITISH S.G. IRON PRODUCERS' ASSOCIATION has been formed from among the licensees in Great Britain and Northern Ireland under British Patent No. 630,070 and others for producing spheroidal-graphite iron castings. MR. P. A. RUSSELL and MR. W. R. COOPER have been elected chairman and vice-chairman, respectively, and MR. C. GRESTY has been made hon. treasurer. The secretariat and offices are at 94-98 Petty France, London, S.W.1.

MARTIN, BLACK & CO. (WIRE ROPES) LTD., Speedwell Works, Coatbridge, near Glasgow, have opened their new Midlands office at 4 Low Pavement, Nottingham. (Telephone: 47293-4.) Mr. H. Arkless is in charge.

Most of the divisions and subsidiary companies in the D.C.L. INDUSTRIAL GROUP are now moving from their present London offices to new accommodation in Devonshire House, Mayfair-place, Piccadilly, London, W.1. (Telephone: MAYfair 8867.) Associated with these changes, MAGNESIUM ELEKTRON LTD. are to move to Distillers House, 20-21 St. James's-square, S.W.1. (Telephone: WHItehall 1040.)

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Obituary

MAJOR C. J. STEWART

Wartime Aircraft Production

We record with regret the death of Major Charles John Stewart, C.B., O.B.E., Wh.Ex., M.I.Mech.E., F.R.Ae.S., late deputy controller of production in the Ministry of Aircraft Production. Major Stewart died suddenly at Pitlochry, Perthshire, on May 7.

Charles John Stewart was born at Portsmouth on November 23, 1881, and received his technical education at H.M. Dockyard School and Technical Institute, Portsmouth, and the Royal College of Science, London. In 1903 he became an assistant examiner in H.M. Patent Office, a position which he held until 1913, when he was appointed H.M. Inspector of Engineering Education.

In 1914 he joined the Royal Engineers (West Midland Division), and in the following year was promoted to field rank. In 1917 he transferred to the Royal Flying Corps as an experimental officer, and subsequently became a Squadron Leader in the Royal Air Force. In 1919, the year in which he received the O.B.E., he became head of the Instrument Research Section of the Air Ministry, and was transferred to Farnborough in 1925.

In 1931 he was appointed Superintendent of Development at the Royal Aircraft Establishment, Farnborough, a post which he held until 1938. In 1939 he became Director of Civil Research and Production at the Air Ministry. The following year he was appointed Director-General of Production in the Ministry of Aircraft Production, and from 1942 until his retirement in 1945 he was Deputy Controller of Production. He received the award of C.B. in 1942. After leaving the service in 1945 he set up as a consulting engineer. For many years he was technical adviser to Dowty Equipment, Limited, on fuel systems, and recently he joined the board of Dowty Fuel Systems, Limited.

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DR. F. A. WILLCOX

A Pioneer of Refrigeration Engineering

It is with regret that we note the death of Dr. F. A. Willcox, of 10 Crescent-road, Sidcup, Kent, which occurred at the Middlesex Hospital on May 7, at the age of 83. Frank Ainsworth Willcox, who was a director of J. and E. Hall, Limited, Dartford, Kent, was the son of the late Mr. S. W. Willcox, a consulting engineer, of Sunderland, and was born in Lewisham, Kent, now a suburb of S.E. London, and received his technical education at Armstrong College, Newcastle-upon-Tyne. He was subsequently awarded the degree of Doctor of Science by the University of Durham.

After serving for a period as science master at Burton-on-Trent Grammar School, Mr. Willcox entered industry as an assistant engineer and chemist to the Smokeless Powder Company, and later became manager of the military powder department of the American E.C. and Shultze Company. Subsequently he joined his brothers in the firm of Willcox Brothers, Sunderland, then and still at the present time the agents of J. and E. Hall, Limited. Here Mr. Willcox took an active part in the early development of refrigeration on fishing trawlers. He joined J. and E. Hall in 1909 and became technical director two years later when the science of refrigeration was developing rapidly. He combined technical knowledge with the ability to deal with financial questions and for that reason became director in charge of the financial side of the organisation.

Dr. Willcox was elected a member of the Institute of Refrigeration in 1910 and was made President in 1935. He became a member of the Institution of Chemical Engineers in 1927 and had served on the Council. He was a member of the Board of Governors of the Dartford Technical College and its chairman for many years and was also a member of the Engineering Committee of the Food Investigation Board of the Department of Scientific and Industrial Research for about 25 years.

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We regret also to record the deaths of the following:

MR. W. ARTHUR BAIRD, in Sydney, New South Wales, Australia, on May 7, at the age of 63. Mr. Baird was formerly engineering manager, Qantas Empire Airways Ltd.

MR. FRANCIS MARTIN LUTHER, on May 13, at his home at Haywards Heath, Sussex. He had been managing director of Beardmore Motors Ltd. since the foundation of the company in 1919, and previously managing director of the Beardmore Aero-Engine Company. Mr. Luther was a pioneer of the application of the internal-combustion engine to road vehicles and aircraft.

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THE SOCIETY OF ENGINEERS' CENTENARY BANQUET

Presentation of Churchill Gold Medal to Sir W. Wallace

The centenary of the founding of the Society of Engineers (Incorporated) was celebrated with a banquet at the Hall of the Fishmongers Livery Company, in London, on May 7. Telegrams of good wishes from the Australian branch, the Royal Aeronautical Society, the Association of Engineers of Uruguay, and members at home and abroad, were read to the members and their guests.

The President, Mr. W. R. Howard, M.I.Struct.E., in responding to the toast of the Society, which was proposed by Major-General K. C. Appleyard, C.B.E., M.I.Mech.E., said that the Society had been honoured by the consent of the Duke of Gloucester to become their Patron. He announced the establishment by the Society's Scottish branch of the Baker Medal (in memory of Sir Benjamin Baker), and said that the first award of it was to be to Professor J. E. Richey, consulting geologist.

Presenting the Churchill Gold Medal to Sir William Wallace, C.B.E., M.I.Mech.E., the President recalled that Sir Winston Churchill had accepted nomination as an Honorary Fellow soon after the war. The first award of the medal had been made two years ago to Sir Frank Whittle. Sir William Wallace, who was receiving the second award, was the patentee of the Denny-Brown ship stabiliser and had been responsible for the design of the steering gears for the Queen Elizabeth and the Queen Mary. He was President of the Institution of Engineers and Shipbuilders in Scotland and the vice-president of the Institute of Marine Engineers. Sir Winston Churchill, Mr. Howard said, had written to Sir William Wallace to congratulate him and to express his regret at not being present at the banquet. Sir William also received a scroll of honorary fellowship of the Society.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

New Premises in London

The new headquarters of the Institution of Heating and Ventilating Engineers at 49 Cadogan-square, London, S.W.1, are situated in as pleasant and quiet a spot as one could hope to find reasonably near the centre of the Metropolis. Sloane-street and Knightsbridge are only a few minutes' walk away.

The ground floor, first and second floors and basement of the building are occupied by a Council room, secretary's office, library and members' room, general office, accounts office, etc. The offices are considered to be of sufficient size to allow for expansion of the staff within the fore seeable requirements of the Institution. The move to the new premises, which have been purchased on a 70-year lease, was completed last November.

A RESEARCH ASSOCIATION

The possibility of founding a research association to serve the heating and ventilating engineering industry (in the widest sense) is occupying the attention of the Institution at the present time. If guarantees can be arranged with the industry for a sufficient annual income, the Department of Scientific and Industrial Research would doubtless make a grant on a similar basis to that on which existing research associations work. Though the Institution are taking the lead in promoting the establishment of a research association, it is more than likely that, once the association is founded, it will be controlled by a governing body modelled on the pattern of existing bodies of that type.

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THE INSTITUTION OF ENGINEERS-IN-CHARGE

The 49th annual dinner of the Institution of Engineers-in-Charge was held at the Holborn Restaurant, London, W.C.2, on Friday, May 14, the chair being taken by the President, Sir William A. Stanier, F.R.S., M.I.Mech.E. The guests included Mr. H. A. R. Binney, C.B., Director of the British Standards Institution, who proposed the toast of "The Institution."

It had been said, Mr. Binney remarked, that in Britain there was a tendency to put social security before efficiency; but in practice it was impossible to have social security without efficiency. It was a primary object of the Institution of Engineers-in-Charge to promote that efficiency, which was so important at the present time.

Sir William Stanier, in responding to the toast, said that the Institution was essentially one for the practical man. Many people were too much inclined to think that the scientific type of engineer was the only one that mattered, but it was the practical man who had "to produce the ironmongery." Major-General Lloyd, the Director of the Department of Technology in the City and Guilds Institute, replying to the toast of "Our Guests and Friends," proposed by Mr. R. L. Quertier, said that, despite all the arguments about technological education, he endorsed what the President had said regarding the training of practical men. The City and Guilds Institute was the only national body that was solely concerned with the craftsman, the technician and the operative.

At the outset of the proceedings, on the motion of the President, a telegram of loyal greeting was sent to Her Majesty the Queen, at that time proceeding up the Solent in the Royal Yacht Britannia on the last stage of her Commonwealth tour. Sir William Stanier having been obliged to leave before the conclusion of the programme of speeches and entertainment, the reply was read by Mr. Robert Chalmers, O.B.E., the immediate past President of the Institution, and was received with acclamation.

INDUSTRIAL GAS CONFERENCE

Relation of Gas and Steel Industries

An industrial conference, in connection with the British Industries Fair, was organised by the Gas Council on May 10 and 11, at Ashorne Hill, near Leamington, Warwickshire. The conference was preceded by a luncheon at Chesford Grange Hotel, Kenilworth, on May 10, at which Colonel Sir Harold Smith, K.B.E., chairman of the Gas Council, took the chair. Sir Harold, in introducing the principal guest, Mr. E. Julian Pode, A.C.A., J.P., managing director of the Steel Company of Wales Limited, referred to the relative costs of coal and gas. Coal, he said, had risen in cost by about 300 per cent. since 1938, but the gas industry had managed to keep the cost of gas at less than double what it was before the war. The industry was striving to meet the increase in coal costs by improving the efficiency of its plants, by developing methods of gasifying coals which are plentiful but not of good gasmaking quality, by using sources other than coal, and by exploring the possibility of finding natural gas in commercial quantities.

Sir Harold then called on Mr. Pode to deliver his address on the "Relation of the Gas and Steel Industries." Mr. Pode stated that carbonisation of coal is carried out by two main industries, the gas and the coking undertakings. The coking industry carbonises 26 million tons of coal annually, the production being divided between the National Coal Board with 50 plants using 10 million tons, the iron and steel industry with 24 plants consuming 13¾ million tons, and independent owners with eight plants requiring 2¼ million tons. Mr. Pode went on to say that the organisation of these branches of the industry is complex, for while the colliery coking plants make and sell gas, the Gas Boards make, buy and distribute, and the steel industry makes, consumes, sells and buys gas. He pointed out that in many cases iron and steel works, though they make very large quantities of gas, do not produce enough to meet their own fuel requirements, and, it might well be asked, why should they sell any gas at all? The answer lies in a combination of technical and economic questions, and it may well be an economic proposition for an iron and steel works to sell some of its gas and make up its heat requirements with other fuel. Similar considerations applied with another product of coal carbonisation, coke, and, Mr. Pode said, the answer lay in co-ordination of the work of the coal, gas and steel industries, which was fully recognised by Parliament. The recently-created National Industrial Fuel Advisory Service was interested in the questions he had mentioned

Papers discussed on May 11 dealt with post-aerated burners, industrial selling, service to industry, and the industrial use of gas in Wales.

THE NEWCOMEN SOCIETY

Dickinson Memorial Lecture and Medal

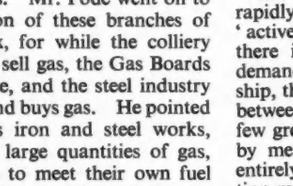
The first biennial Dickinson Memorial Lecture to the Newcomen Society for the Study of the History of Engineering and Technology was delivered by Dr. Charles Singer on May 12 in the Science Museum, South Kensington, the chair being taken by the President of the Society, Mr. Rex Wailes, M.I.Mech.E., F.S.A. The Lecture has been established, in collaboration with the North American affiliated Newcomen Society, to commemorate the long association with the Society, and the valuable work, of Dr. Henry Winram Dickinson, M.I.Mech.E., who was a founder member, President in 1932-34, honorary secretary for more than 30 years, and editor of the first 25 volumes of the *Transactions*.

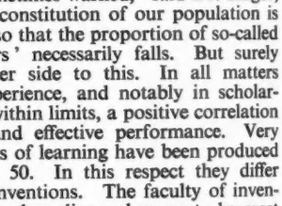
Dr. Singer, who had been a close personal friend of Dr. Dickinson for many years and had been associated with him in many historical researches, said that, if his lecture required a title, he would like to call it "The Happy Scholar," for that most aptly described Dickinson's character and life. Simplicity, and the dignity and magnanimity that stemmed from it, were among the marks of scholarly greatness, and Dickinson had them in full measure.

The most significant events of Dickinson's official career, continued Dr. Singer, were the acquisition and arrangement of some of the more important historical exhibits at the Museum, among them the early Watt engines and James Watt's garret workshop, which was transferred complete from Watt's house near Birmingham. The life and work of Watt became Dickinson's close study and was the subject of more than one of his books; but Watt also influenced his career in another way, for it was as a result of the commemoration, in 1919, of the centenary of Watt's death that the Newcomen Society was founded in 1920. Thus it came about that the main achievement of Dickinson's life was compressed into the last 30 years of it.

"We are sometimes warned," said Dr. Singer, "that the age constitution of our population is rapidly rising, so that the proportion of so-called 'active workers' necessarily falls. But surely there is another side to this. In all matters demanding experience, and notably in scholarship, there is, within limits, a positive correlation between age and effective performance. Very few great works of learning have been produced by men under 50. In this respect they differ entirely from inventions. The faculty of invention matures much earlier and seems to be most active between 20 and 40. Certainly, had Dickinson died before he was 60, his achievement would have been very inferior to what it was. But as it is I have no doubt that the publications of the Newcomen Society up to 1952 will be regarded, for many generations, as the foundation of a new discipline and as a first sign of the broadening of technical education."

On the conclusion of the lecture, the President handed to Dr. Singer the commemorative Dickinson Medal, which is illustrated below. It is 2 in. in diameter, of oxidised bronze, and bears on the obverse the Newcomen Society's badge of a gryphon segreant with the motto, due to the late Colonel E. Kitson Clark, *Actorum memores simul affectamus agenda*, which may be freely translated as "Remembering the deeds of the past we strive after those still to be done."





Obverse and reverse of the medal which was presented to Dr. Charles Singer after he had delivered on May 12 the first biennial Dickinson Memorial Lecture, as reported above.

MOTOR YACHT "ARIES"

To Make Double Crossing of Atlantic

Towards the end of this month—probably on May 22—the converted motor lifeboat Aries will leave Kingston-on-Thames on a voyage to the United States and back; the first occasion on which this double crossing has been attempted with a power-driven vessel of such small size. The Aries was built in 1929 by Messrs. Saunders-Roe, Limited, of Cowes, Isle of Wight, for the Royal National Life-boat Institution, under the name of Princess Mary and was stationed at Padstow, Cornwall. At the time, she was the largest lifeboat in the world, being 61 ft. in length and 15 ft. beam, with a displacement of 45 tons. She was designed to remain afloat and still manageable after shipping about 70 tons of water, and could carry between 50 and 60 passengers in her two cabins, and, in moderate weather, 250 on deck.

In 1953 she was bought by Captain C. Harcourt-Smith, R.N. (ret.), who is now manager of the Marine and Aircraft Division of Messrs. Venner Electronics, Limited, under whose direction she has been refitted by Messrs. Tough Brothers, Limited, of Teddington, Middlesex, to undertake the double Atlantic crossing. Two six-cylinder 120-h.p. Diesel engines have been supplied by Messrs. Fodens, Limited, of Sandbach, Cheshire; and eight fuel tanks, holding together about 2,500 gallons (11½ tons) of fuel oil, have been fitted, in addition to three daily service tanks. They were fabricated by Whittingham and Mitchell, Limited, Byfleet, Surrey, as also were the water tanks, from B.A.27 aluminium alloy, the gift of the British Aluminium Company, Limited. They are of $\frac{3}{16}$-in. plate, with baffles of $\frac{1}{8}$-in. plate, and to economise space, are shaped to fit closely to the form of the hull. They are welded throughout by the Argon-Arc process. The engines drive the propellers through gearing made by the Self-Changing Gear Company, Limited. The crew will consist of four, including the owner.

WIRELESS EQUIPMENT

Advantage is being taken of the exceptional circumstances of the voyage to fit the vessel with an unusually complete installation of wireless equipment. With the co-operation of the Admiralty, the Aries has been provided by Messrs. Rees Mace Marine, Limited, who are the marine subsidiary of Pye, Limited, of Cambridge, with one of their recently-developed Admiralty-type sets, known as Type 619, and the corresponding receiver, designated the CAT. A large number of these sets are being delivered to the Admiralty. In addition, a V.H.F. radio-telephone equipment of Messrs. Pye's type PTC.117 is being fitted for communication with aircraft; it is operated from 12-volt batteries and has a range from ship to aircraft of about 150 miles. The main radio equipment requires single-phase alternating current at 50 to 60 cycles and 100 to 125 and 200 to 250 volts. As the ship's electricity supply is direct current at 220 volts, a rotary converter has been supplied by Messrs. Auto-Diesels, Limited, Uxbridge.

The principal ship-to-shore communication will be to the various Commonwealth naval and commercial radio stations, using high-frequency channels in the 4, 6, 8 and 12 millicycle bands. Communications to the naval wireless stations will be by wireless telegraphy; but, in addition, the shore stations of the Royal Naval Wireless Volunteer Reserve at London, Kingston and Windsor expect to receive radio-telephone calls from the Aries. Arrangements have been made with the Meteorological Office of the Air Ministry for the ocean weather ships on the yacht's course to provide communications facilities, by wireless telegraphy on 500 kilocycles and by V.H.F. radio-telephone on 121·5 millicycles; the Royal Air Force and the various transatlantic air lines are co-operating to maintain touch with the vessel; and amateur radio operators who are members of the Radio Society of Great Britain and the Radio Relay League of America, as well as individual groups of amateurs in various European countries, will be listening for signals. These amateur reports will be forwarded to the R.N.W.V.R. headquarters at Kingston.

It is expected that the westward voyage will take about 20 days. The Aries will remain in United States waters for seven to ten days, and is expected to be back in the Thames by about July 17.

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INSTITUTION OF ELECTRICAL ENGINEERS

Annual Report

The Council's report for the year ended March 31, 1954, was presented to the Institution of Electrical Engineers at their annual general meeting on May 20.

The Council state that the growth of membership has been maintained, but not at a rate which is adequate to meet the country's increasing need for professional engineers. Much attention was therefore paid to the questions of education and recruitment. Collaboration was maintained with the Ministry of Education towards utilising to the full the "middle stream" of technological education, particularly with regard to sandwich courses, and a Joint Advisory Committee was set up by the Presidents of the three engineering institutions. The main subject discussed was a proposal for a new national award in technology. This was also discussed with the Ministry of Education and the National Advisory Council. Work on the preparation of a 13th edition of the Wiring Regulations was proceeding and five more Codes of Practice were published during the year.

The Council continued to encourage the use of the rationalised M.K.S. system of units, and with revised syllabuses of the Institution Examination reference is made to this system in the compulsory electrical subjects in all three Parts. However, other recognised systems will still be acceptable in most questions.

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ELECTRIC POWER TRANSMISSION IN EUROPE

Anniversary Meeting in Paris

The 60th anniversary of the foundation of the École Supérieure d'Électricité was celebrated by a meeting at the Palais de Chaillot in Paris on Wednesday, May 12. Mr. R. Gaspard, general manager of Electricité de France, presided and introduced Mr. P. Ailleret, who is manager of the Research Department in this organisation. Both of these gentlemen, incidentally, are former pupils of the school. Mr. Ailleret then delivered a lecture on "The Evolution of Electric Power Transmission in Europe," in the course of which he gave an account of the development of the overhead-line system in Europe since the year 1922.

He pointed out how these systems had become increasingly interconnected. Thirty years ago the means of constructing the towers and lines were already well known, but there was no great need for this knowledge owing to the small demand for power. As this demand increased however, it was necessary to develop more remote sources and this, in turn, led to the use of higher transmission voltages. It was possible that the limit had now been reached in this direction; and that these long lines would become of less importance, especially as water-power resources became fully developed and new methods of generation, like the gas turbine and atomic power, were more extensively used. The siting of stations containing such plant would not be so limited as were those of present plants; and the blocks of power transmitted being less the solution of the circuit-breaker problem would become easier. As regards transmission lines, many advances had been made in the design of the towers, which were now smaller and lighter than they had been, even for the higher voltages. A further economic question of some importance was whether it would be better to transmit power or to transport coal for use in stations near the load centres. All these points had their relation to technical education and Mr. Ailleret concluded by expressing with some force his view that early specialisation was to be deprecated.

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BOOK REVIEWS

The Technical Lecture. A Guide to Authors and Chairmen. By A. H. WILLIS, B.Sc.(Eng.), Ph.D., Wh.Sc. *Quest Publications*, 17 *Driver-street, West Ryde, N.S.W., Australia.* (8*s.* 6*d.* Australian. 7*s.* sterling from U.K. booksellers.)

A glance at the last page of any issue of this journal will convey an idea of the number of technical lectures delivered, or papers read, each week in this country. It may be assumed that the authors of these very varied addresses are familiar with the subjects on which they speak and know what particular information they wish to convey to their audiences, but, as few of them are likely to be practised public speakers, they may not know how best to prepare and deliver their material.

Anyone in the habit of attending meetings of technical institutions will recollect cases in which an author has read through a prepared document in a monotonous voice with his head inclined over his manuscript instead of being erect to face the audience; others in which complicated diagrams, which require at least ten minutes study properly to comprehend them, have been shown on a screen for half-a-minute or less, often with lettering and figures so small that they could not properly be seen by persons sitting half-way down the hall. He will also have recollections of a speaker spending most of his time making sketches on the blackboard with his back to his audience so that he is only imperfectly heard.

It is Professor Willis's purpose in this book to provide instruction and hints which if followed might improve the presentation of many, perhaps most, technical lectures. He suggests that the importance of good oral presentation is greater than that of good written presentation. A printed paper which is badly written and arranged, if of sufficient technical value, may be read many times and obscure passages studied, but this is not possible when a paper is presented orally.

It is the practice of the major institutions to print papers in advance. They are frequently too long for full presentation at a meeting and an author often contents himself with reading selected passages. This results in a jerky and disconnected presentation. As Professor Willis says, a separate manuscript should be prepared for presentation at a meeting. The same principle applies to complicated diagrams: simplified versions, accentuating the particular points brought out in the paper, should be prepared for the meeting. These are but examples of

the many points dealt with, and suggestions put forward, in this useful book. The arrangement of the matter of papers and the choice of language are given attention equally with questions of actual delivery. A careful study of this book would improve the demeanour and the presentation-manner of most authors who deliver papers at technical meetings and would not only tend to increase the interest displayed by the audience but would add to their understanding of the subject.

Galvanizing Techniques in the U.S.A. *Organisation for European Economic Co-operation, 2 Rue Andre-Pascal, Paris* (16*e*); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (9*s.*)

Comparisons between an industry in the United States and its counterpart in any European country have, of necessity, to take into account the difference in size between the two countries and in such circumstances an effective comparison is often difficult. The present report is the work of a group of 29 experts from 12 European countries who visited the United States in 1951. The report points out that Western Europe, with the United Kingdom, represents a unit comparable in many ways with the United States. This is particularly true of the hot-dip galvanising industry. The group came to the conclusion that if economic and industrial co-operation between the Western European countries could be made a reality, and the European galvanising industry could become as closely integrated as that in the United States, the European industry could develop on similar lines to that in America. The report stresses the fact that there are individual works in Europe using methods of manufacture and producing articles at least as good as any found in the States. There is, on the whole, a higher degree of mechanisation in America than in Europe, and there are, of course, more of the large plants involving very high capital cost, which the American market can support. Nevertheless, by no means all the American plants are large; there are some which are quite small, and carry out " jobbing " work of the type commonly found, for example, in Great Britain. The group discovered that even in this country, where large-scale mechanisation is impracticable, great attention had been paid to the questions of labour saving and material flow.

The report is divided into seven sections, four of which are concerned with a detailed study of the main branches of galvanising; sheet and strip, tube, wire and wire products, and general finished products. Other sections are devoted to technical questions common to the whole industry, management and labour, and statistics relating to the industry on both sides of the Atlantic. In the sheet and strip section of the industry the emphasis in the United States is on continuous processes, but it is noted in the report that where such processes are used in Europe, they are virtually the same as those in America. Tube galvanising is much the same in both, the main difference being that much more tube is galvanised in America than in Europe; electrical conduit provides a particular example. Otherwise, there is little difference, and the productivity figures are comparable. Galvanising of wire in the U.S.A. impressed the group, and the part played by well-trained and co-operative labour is stressed.

In the galvanising of general finished products the group notes the advantages of standardisation of product, which is general in America, and leads to easier mechanisation of processes. The report, however, draws attention to the fact that even where a job is of short duration, lasting only for one shift or less, considerable attention is paid to the question of handling methods. Several examples of simple but effective devices used in the American plants are given. In general technique the principal difference noted is the almost universal use of sulphuric acid for pickling in the United States, instead of the hydrochloric acid which is common in Europe.

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Dial Gauges for Linear Measurement (excluding Lever Type). (3*s.*, post free.)

Dial gauges are among the most widely used of engineers' precision instruments and many developments in design have taken place since B.S. 907 was first issued in 1940. A revision, now issued, takes account of this in specifying standards of performance. Several modifications, which experience of working to the previous edition has shown to be desirable, are also incorporated. Moreover, provision is made for the back plunger type of dial gauge now in very general use. In English measure, two types of dial graduations are provided for, namely, those divided into units of 0·001 in. (sometimes subdivided into half units of 0·0005 in.) and known as one-thousandth inch gauges, and those divided into units of 0·0001 in. and known as one-ten-thousandth inch gauges. In metric measure, the standard is confined to dials graduated in units of 0·01 mm. Recommended dimensions, methods of testing and notes on the care and use of dial gauges are given in appendices.

Chains and Wheels for Single-Bottle Width Slat Conveyors. (2*s.* 6*d.*, post free.)

A new standard, B.S. 2075, covering chains and wheels for single-bottle width slat conveyors has been prepared under the authority of the Dairying Industry Standards Committee, but the compilers hope that it will prove of advantage to all industries which employ this type of conveyor for transporting bottles of about the same size as milk bottles. Owing to the fact that the adoption of a standard form of integral-slat conveyor would necessitate some modification to all existing designs, the compilers have decided to confine this Standard to the roller-chain and slat-band chain types of conveyors. Details of the materials and the dimensions of both the chains and the slats, together with tolerances, are specified.

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TRADE PUBLICATIONS

Directory of British Construction Equipment, 1954. The Federation of Manufacturers of Contractors Plant, 121 Queen Victoria-street, London, E.C.4, has sent us a copy of their new directory which is handsomely produced, copiously illustrated and printed with the text in English, French and Spanish. Fifty-one British firms who specialise in the manufacture of contractors' plant have contributed to the directory, which is prefaced by a tabulated statement showing, at a glance, which firms specialise in one or more of the 126 different categories of equipment listed. The directory concludes with numerous useful tables and also data relating to the characteristics of air-compressors, pumps, wire-ropes, etc. A very large range of plant has been included and the directory is, therefore, a valuable reference book for engineers and contractors alike.

Dielectric Heating. An illustrated handbook dealing with the principles and applications of dielectric heating has been issued by the Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester, 17. The mode of action of the heating is discussed and then examples are given of its applications in the wood-working, plastics, textiles and foodstuffs industries and in medical work. Moisture extraction and drying generally also offer scope for its use.

Transformer Installation. Recommendations on the installation and maintenance of oil-filled post-type current transformers operating from 88 to 275 kV are given in a booklet published by A. Reyrolle & Co., Ltd., Co. Durham.

Process Controller. A leaflet published by the Cambridge Instrument Co., Ltd., 13 Grosvenor-place, London, S.W.1, describes a process controller originally designed for use in rubber vulcanising. It has a 2-pen thermograph with a reverse acting regulator linked to each pen, and a set of clockwork driven adjustable cams. An air supply at 15 to 17 lb. per sq. in. is required.

Protection Relays. A. Reyrolle & Co., Ltd., Hebburn, Co. Durham, have issued a revised edition of their handbook of protection relays. The book has 68 pages and describes in detail some 30 relays divided into groups according to operation.

BOOKS RECEIVED

The Operation and Maintenance of Vertical Boilers. By SYDNEY D. SCORER. *John D. Troup, Limited, 90 High Holborn, London, W.C.*1. (4*s.*)

Fire and the Atomic Bomb. By D. I. LAWSON. Fire Research Bulletin No. 1. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

Energy Transfer in Hot Gases. National Bureau of Standards Circular 523. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (1·50 dols.)

The Use of Stabilized Soil for Road Construction in the U.S.A. By K. E. CLARE. Road Research Technical Paper No. 29. *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

Materials and Processes. By JAMES F. YOUNG. Second edition. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York* 16, *N.Y., U.S.A.*; and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.*2. (68*s.*)

Strength and Elasticity of Materials. Vol III: Solutions to Examination Questions of the University of London. By W. H. BROOKS. *Macdonald and Company (Publishers), Limited, 16 Maddox-street, London, W.*1. (25*s.*)

Microscopical Techniques in Metallurgy. By HENRY THOMPSON. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (18*s.*)

Exporting to Canada. Published for the Board of Trade by *H.M. Stationery Office, Kingsway, London, W.C.*2. (3*s.*)

Injury Experience in the Coking Industry, 1951. By SETH T. REESE, NAOMI W. KEARNEY and ELIZABETH A. MILLER. United States Bureau of Mines Bulletin No. 527. *The Superintendent of Documents, U.S. Government Printing Office, Washington,* 25, *D.C., U.S.A.* (25 cents.)

Effective Radio Ground-Conductivity Measurements in the United States. By R. S. KIRBY, J. C. HARMAN, F. M. CAPPS and R. N. JONES. United States National Bureau of Standards Circular 546. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (65 cents.)

Britannica Book of the Year, 1954. Events of 1953. *Encyclopædia Britannica, Limited,* 90 *Dean-street, London, W.*1. (63*s.*).

The Modern Diesel. Automotive Oil Engines for Transport, Marine and Industrial Use. By DONALD H. SMITH. Twelfth edition. *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.*1. (12*s.* 6*d.*).

Electrical Measuring Instrument Practice. By E. H. W. BANNER. *United Trade Press, Limited, Boswell House,* 9 *Gough-square, London, E.C.*4. (15*s.*)

Questions and Answers on Distribution and Use of Electric Power. By T. H. CARR. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.*2. (6*s.*)

Questions and Answers on Power Station Practice and Plant. By T. H. CARR. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.*2. (6*s.*)

Pest Infestation Research, 1953. Report of the Pest Infestation Research Board. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.*)

Chemistry Research, 1953. Report of the Chemistry Research Board. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.*2. (2*s.* 6*d.*)

At Work for Europe. An account of the activities of the Organisation for European Economic Co-operation. *Organisation for European Economic Co-operation, Information Division, 2 Rue André-Pascal, Paris* (16*e*). (Free on application.)

Foreign Trade Zones in the U.S.A. Technical Assistance Mission No. 28. *Organisation for European Economic Co-operation, 2 Rue André-Pascal, Paris* (16*e*) (240 francs); and *H.M. Stationery Office, Kingsway, London, W.C.*2. (4*s.* 6*d.*)

Electron Physics. U.S. National Bureau of Standards Circular 527. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (2·75 dols.)

Performance and Efficiency Tests with Exhaust Steam Injector. British Railways standard Class 5, 2-cylinder 4-6-0 mixed traffic locomotive. *The British Transport Commission,* 222 *Marylebone-road, London, N.W.*1. (10*s.*)

Spring Meeting of the Institute of Metals (*continued from page* 583)

CONTROL OF QUALITY IN WROUGHT METALS

Continuing our report of the joint spring meeting of the Institute of Metals with the Société Française de Métallurgie we give a summary of the proceedings of Tuesday afternoon, April 27.

Members of the Société visited the Crayford Works of Frederick Braby and Company, Limited, and the Greenwich Works of the Telegraph Construction and Maintenance Company, Limited, and Submarine Cables, Limited, also the National Physical Laboratory and the Chemical Research Laboratory of the Department of Scientific and Industrial Research, at Teddington.

Members of the Institute of Metals attended a scientific session at Church House, Westminster, at which three papers were presented.

METAL ENTRAPMENT IN FLUX

The first paper considered described "An Investigation of Thickening and Metal Entrapment in a Light-Alloy Melting Flux," an investigation sponsored at the Fulmer Research Institute, Stoke Poges, by International Alloys, Limited, Aylesbury. The authors, Dr. A. H. Sully, Dr. H. K. Hardy and Mr. T. J. Heal, said that fluxes based on alkali chlorides used in remelting aluminium alloys became thickened and dry in service, especially when the charge was in the form of finely-divided metal. The thickened flux contained, trapped within it, an appreciable proportion of metal. An investigation had been made of flux samples taken from industrial furnaces, and also of synthetic fluxes, to determine the reason for flux thickening and metal entrapment. The latter was attributed to an increase in viscosity due to the presence of alumina films, stripped by the flux by surface-tension forces from the metal surface. Measurements of viscosity of molten fluxes at 850 deg. C. had shown that the increase of viscosity caused by a dispersion of alumina in molten flux was critically dependent upon the shape of the alumina particles, being very great for particles that were thin and flat. The viscosity of the thickened flux could be reduced by stirring. Agglomeration of all but the smallest particles of aluminium trapped in the flux could be effected by stirring, and the efficacy of the treatment in practice was determined by the range of particle sizes and by the practicability of stirring.

PROPERTIES OF ALUMINIUM-MAGNESIUM-SILICON ALLOYS

The next two papers both dealt with the properties of aluminium-magnesium-silicon alloys and were presented jointly. The first, entitled "The Effect of Iron, Manganese and Chromium on the Properties in Sheet Form of Aluminium Alloys Containing 0·7 per cent. of Magnesium and 1·0 per cent. of Silicon," was by Mr. R. Chadwick, Mr. N. B. Muir and Mr. H. B. Grainger, of Imperial Chemical Industries, Limited, Metals Division, Birmingham. The authors stated that as part of a systematic investigation of alloys hardened by magnesium-silicide precipitation, the effects of 0 to 0·4 per cent. of iron and 0 to 0·6 per cent. of manganese or chromium had been assessed in materials of constant magnesium and silicon content. The alloys had been hot and cold rolled to sheet and it had been found that, after solution heat-treatment and room-temperature ageing, the properties varied only slightly with composition, strengthening being brought about by all three alloying additions. After subsequent artificial ageing at 160 deg. C., alloys free from manganese or chromium were brittle and exhibited intercrystalline fracture in tension. Alloys containing manganese or chromium were both stronger and more ductile, fracture being mainly transcrystalline. Corrosion-resistance was high in the room-temperature-aged materials, but susceptibility to intercrystalline attack was induced by artificial ageing.

The second paper on aluminium-magnesium-silicon alloys was a communication from the research laboratories of the British Aluminium Company, Limited, Gerrards Cross, Buckinghamshire, by Mr. I. R. Harris and Major P. C. Varley, M.B.E. It was entitled "Factors Influencing Brittleness in Aluminium-Magnesium-Silicon Alloys" and the authors stated that the effects of composition, heat treatment, cold work and structure on the brittleness and mechanical properties of a series of wrought aluminium-magnesium-silicon alloys containing 0 to 2 per cent. of silicon and 0 to 2 per cent. of magnesium, had been investigated. It had been found that brittleness in the fully heat-treated alloys which were completely recrystallised with equiaxed grains was dependent on composition. When the alloys were solution-treated at 540 deg. C., and subsequently precipitation-treated at 175 deg. C., for 8 hours, excess silicon had been found to be necessary for brittleness, but, for the same degree of brittleness, the amount required varied with the percentage of magnesium silicide and iron present.

Microscopic examination after etching indicated that maximum brittleness, as denoted by an Izod impact value of about 3 ft.-lb., was probably associated with the preferential grain-boundary precipitation of either free silicon or magnesium silicide, or both, to form a continuous network. The continuity of the grain-boundary network was dependent on the solution-treatment temperature, the rate of cooling from this temperature, and the precipitation-treatment conditions.

As has now become customary at meetings of the Institute of Metals, several simultaneous sessions were held on the following day, April 28.

CONTROL OF QUALITY IN WORKING WROUGHT METALS

The programme at session "A," at which Dr. S. F. Dorey presided, consisted in the presentation and discussion of a symposium of five papers on "The Control of Quality in the Working Operations of Wrought Non-Ferrous Metals and Alloys." The first paper dealt with "Statistical Control in Metal-Working Operations," by Mr. M. Whyte of the research laboratories of the British Aluminium Company, Limited; the second referred to "Problems of the Control of the Dimension, Shape, and Finish in the Rolling of Sheet and Strip and in the Drawing of Wire," by Professor H. Ford, of Imperial College, London, and Mr. J. G. Wistreich, of the British Iron and Steel Research Association, Sheffield; the third was entitled "The Control of Quality in the Hot and Cold Rolling of Aluminium and Aluminium Alloys," by Mr. F. King, of the Northern Aluminium Company, Limited, and Dr. A. N. Turner, of Aluminium Laboratories, Limited; the fourth was concerned with "The Control of Properties and Structure in the Hot and Cold Rolling of Copper and Copper-Base Alloys," by Mr. W. W. Kee, of the Enfield Copper Refining Company, Limited, Enfield; and the fifth dealt with "Some Factors Affecting the Quality of Extrusions" and was by Mr. Christopher Smith, of James Booth and Company, Limited, and Dr. Norman Swindells, of McKechnie Brothers, Limited, both in Birmingham.

In the first paper, on "Statistical Control in Metal-Working Operations," Mr. M. Whyte stated that in many metal-working processes a quantitative assessment of variability could be used to gain efficiency without fundamental changes to the processes. Sampling rates should be fixed in relation to the quality and homogeneity of the material being tested, and wherever possible material processed as a batch should be the unit which was sampled. Statistical quality control provided a means of ensuring the continuing reliability of routine tests. Statistical methods could be used to assess limits for intermediate variables and qualities which would serve as criteria for the early rejection of material that would finally prove sub-standard.

In the second paper, Professor H. Ford and Mr. J. G. Wistreich examined the general principles of control in relation to the dimensions, shape and finish of sheet, strip and wire. They stated that the control of dimensions in sheet and strip involved the measurement of thickness along the length and across the width. There was a fundamental difference between wire-drawing and rolling in the control of dimensions, because the die bore was of fixed dimensions. Of the three properties, surface finish was the least amenable to measurement and control, and the dependence of finish on the forming process was as yet little understood. Roll finish, die polish and lubricants all affected smoothness and lustre.

In the third paper, on "The Control of Quality in the Hot and Cold Rolling of Aluminium and Aluminium Alloys," Mr. F. King and Dr. A. N. Turner considered the theoretical and practical implications of the control of the tensile strength, bending and pressing properties, corrosion resistance, surface finish, flatness, and uniformity of gauge of aluminium-alloy sheet and strip. A most important variable dealt with was composition. Although the control of composition was usually considered to be the concern of the casting department, compositional limits, to a large extent, must be governed by considerations of the ease of fabrication and final properties of the material. This might apply particularly to the levels of impurity elements which often affected the rolling and annealing properties and corrosion-resistance of wrought alloys.

Mr. W. W. Kee, in the fourth paper, on "The Control of Properties and Structure in the Hot and Cold Rolling of Copper and Copper-Base Alloys," discussed the various phenomena arising during the integrated processes of rolling copper and brass and the methods of controlling such factors as grain-size, directionality, shape, gauge, and surface quality. The paper dealt primarily with the controls exercised on the production of tough-pitch copper and the straight brasses, in sheet and strip form. The author emphasised that cold rolling and grain size had an influence on the properties of the metal, while the control of atmosphere was of importance in annealing operations. Owing to the influence of impurities on processing and structure, every producer should lay down a concentration range for impurities most suitable to his own production methods and requirements.

The fifth, and last, paper in the symposium on the control of quality in working operations dealt with "Some Factors Affecting the Quality of Extrusions" and was by Mr. Christopher Smith and Dr. Norman Swindells. They stated that their paper was mainly concerned with the manufacture of solid products in copper and aluminium alloys on horizontal presses by the direct process. Many of the factors involved were common to both series of alloys, as well as to other types of extrusion, although the importance of any particular feature varied considerably according to the alloy. Extrusion did not readily lend itself to the precise control which was possible with other processes such as rolling and tube drawing. The large number of variables made it extremely difficult to obtain data from which completely unambiguous conclusions could be drawn.

PROFESSOR A. J. MURPHY'S REVIEW

The papers were introduced by Professor A. J. Murphy, who acted as *rapporteur*. He said

that in their paper on the rolling of sheet and strip and the drawing of wire, Professor Ford and Mr. Wistreich had enunciated the following basic principles. The degree to which a property could be controlled depended upon the methods available for measuring it and for correcting any departure from its desired value. The degree of control actually realised then depended upon the accuracy and speed of measurement and the particular methods adopted for exercising the control. The choice of methods was influenced by both technical and economic considerations. The tolerance allowable from the standard of reference was dictated not only by the importance of the property in question but also by the cost of exercising control within the fixed limits of tolerance. Surface finish was said to be the most important single factor determining the sales value of strip and wire, but it was not readily amenable to measurement and, therefore, to control. The relation between surface finish of strip and wire and the smoothness of rolls and dies was fairly clear, but the effect of lubricants was not fully understood.

In their paper on "The Control of Quality in the Hot and Cold Rolling of Aluminium and Aluminium Alloys," Mr. King and Dr. Turner listed the significant properties, which had to be brought to acceptable standards, as the tensile properties, the bending and pressing properties – in which were included earing and grain size – corrosion resistance, surface finish, flatness and uniform gauge.

Mr. Kee, in his paper on "The Control of Properties and Structure in the Hot and Cold Rolling of Copper and Copper-Base Alloys," was chiefly concerned with the production of tough-pitch copper and straight brasses in sheet and strip form. Like Mr. King and Dr. Turner in the case of aluminium, Mr. Kee went somewhat outside his terms of reference by insisting that the influence of impurities in copper and brass must be understood and allowed for in any programme of rolling, especially in hot-rolling and annealing after cold rolling. With reasonable care, breaking-down by hot rolling presented no special difficulties in control. Attention was chiefly concentrated on the attainment of correct final gauge, as delivered to the cold rolls, and the avoidance of surface defects.

The paper made a notable contribution on control during annealing, and the author's outline of requirements for controlled atmospheres in the case of copper and brass was particularly valuable. He laid down the limits for hydrogen concentration in the atmosphere, and showed that embrittlement of tough-pitch copper containing 0·015-0·05 per cent. of oxygen was avoided in an atmosphere containing 2 to 3 per cent. of hydrogen up to 550 deg. C., and this allowed for a normal amount of rolling lubricant on the stock. Hydrogen over 4 per cent. would cause embrittlement. To avoid staining from excessive amounts of entrained lubricant, a slow heating rate to 250 deg. C. should be used. Generally, half-an-hour at 200 to 250 deg. C. in a circulating atmosphere furnace sufficed to volatilise and disperse the oil.

Mr. Christopher Smith and Dr. Norman Swindells, in their paper on the quality of extrusions, stated that extrusion did not lend itself to the precise control which was permissible with other processes such as rolling and tube drawing. The greatest safeguards of quality were still believed to be constant vigilance, intelligent enthusiasm and attention to apparently insignificant detail.

Mr. Whyte, in his paper "Statistical Control in Metal-Working Operations," said that it was seldom true that the problems of an industry were not amenable to statistical treatment. A simple application of statistical analysis to the records of rejection rates in the production of a given article enabled the degree of variation or scatter of quality to be assessed. This could be used to achieve an immediate saving in an existing process without any alteration of technical conditions. The statistical techniques of correlation and regression were useful in studying the relationship between process variables and intermediate or final properties. The object here was to avoid processing material which would ultimately prove to be sub-standard.

Finally, taking the papers as a whole, three questions might be taken as themes for discussion. Firstly, had the knowledge of the nature of the processes involved in rolling and extruding metals now reached the stage at which (*a*) automatic control of quality and (*b*) statistical control of quality could be applied much more extensively? Secondly, if such an extension were feasible and desirable, what would be the consequences or requirements in a re-orientation of inspectional techniques and procedures? Thirdly, was the further extension of these methods of control dependent upon superior techniques in instrumentation compared with those now available?

DISCUSSION

Mr. E. A. Bolton, who opened the discussion, said that several of the papers lay stress on the need for accuracy of dimensions and good shape of the hot-worked product, and it must be agreed that faulty material at this stage could be rectified in the subsequent cold working only by costly means and the expenditure of extra time.

Some stress should be laid on the part played by skilled, experienced and conscientious operatives working under enlightened supervision in the control of quality. This had not been lost sight of by the authors of the papers. Faults could develop which, while obvious at the time to the operative, became covered up by subsequent processing.

Mr. J. F. Kayser said there was one way in which a great deal of money could be saved, and that was if the producer would take the consumer into his confidence so that it was unnecessary for the consumer to examine the material when he received it. In this way, inspection work was halved.

Mr. W. K. Pearson said that metallurgists must agree on the effect of casting temperature; in fact, any of the conditions at the casting stage which affected the rate of freezing of the structure and particularly the constitutional state rather than the grain size. The effect of constitution, which had such a controlling influence on later-stage "earing," seemed to affect the recrystallisation texture rather than the rolling texture. Although high earing could be avoided in super-purity aluminium, the other elements in normal-purity metal could considerably assist earing control when the right processing conditions were ascertained. Mr. King and Dr. Turner had found these conditions readily when ingot quality was constant, but it was generally agreed now that some measure of block treatment, such as a long preheat, was advisable to counteract casting variables.

Dr. A. N. Turner said that Mr. Bolton had referred to the need for skill on the part of operatives and had asked for enlightened technical supervision. While agreeing that the skill of the men in the works was much to be admired, and essential in any process, he felt that the need to rely on it was a confession of lack of technological knowledge and incapacity to control the process.

Mr. A. G. Adlington stated that Mr. Smith and Dr. Swindells had referred to the effects of contaminated furnace atmospheres. Independent work by Struve and Burghoff in America and Canada had drawn attention to these. These workers had shown, in particular, the effects of sulphur contents and moisture in the furnace atmosphere. In the case of those extrusions which usually exhibited coarse grain peripheral zones, the effects were shown as deterioration at or near grain boundaries, and they markedly affected mechanical properties and were apparent after quenching.

Dr. C. E. Ransley dealt with the mysterious effects of furnace atmospheres on the blistering of extruded sections, and particularly alloys containing magnesium. He said that leaving out of account for the moment the question of overheating, which could be readily recognised, it had been known for a long time that heat treatment could produce deleterious effects under certain conditions. It had also been known for some time—in fact, he believed that the original Aluminium Laboratories patent has just expired—that certain fluoride vapours could have a very beneficial effect in offsetting these conditions. Several authors, quite rightly, had stressed the importance of protecting the work as far as possible from the products of combustion in fuel-fired furnaces. That was the right thing to do, but it should be emphasised that these deleterious effects could also occur in electric furnaces and arose from the same cause. The main point was that, although water vapour by itself could lead to an appreciable pick-up of hydrogen by the metal, particularly alloys containing magnesium, the real villain of the piece was sulphur. The sulphur worked by acting as a catalytic agent for the absorption of hydrogen.

The mechanism of the reaction could probably be represented as:

$$3Mg + SO_2 \rightarrow MgS + 2MgO$$

$$MgS + 3H_2O \rightarrow 6H + SO_2 + MgO$$

It was a characteristic of this reaction that a certain amount of staining usually took place, and if the work were allowed to air-cool to room temperature, there was a slight but distinct smell of H_2S. Magnesium sulphide was very readily hydrolysed, and the smell faded away fairly rapidly. Quenching, of course, destroyed it immediately.

Pre-exposure of the metal to HF vapour or the introduction into the furnace of a fluoride slightly volatile at the heat-treatment temperature completely inhibited the reaction, presumably by the preferential formation of a stable magnesium fluoride film. As mentioned earlier, these deleterious effects could occur in electric furnaces and were accompanied by the same characteristics. The source of sulphur in this case was very probably in the oils used for drawing and rolling, and some control over this factor might be possible.

Mr. Frank Kasz said that homogenisation was carried out to relieve internal stresses, promote a closer approach to constitutional equilibrium and facilitate hot working. But homogenisation was not always desirable; it was something of a mixed blessing. For example, if gas control had been inadequate, it could accentuate blisters or cause giant grains in commercial-purity aluminium after high reductions and an anneal at 480 deg. C. – some 70 deg. lower than had been suggested by Mr. King and Dr. Turner. It could also lower the proof and ultimate tensile stresses by 0·3 to 0·7 tons per square inch. It was therefore necessary to control both temperature and time if the desired effects of homogenisation were to be obtained.

Mr. Christopher Smith said that he saw no reason why glass should not be used as a lubricant, if a glass could be found having suitable characteristics at the low temperatures which were necessary for extruding aluminium alloys.

Mr. E. A. Bolton, speaking again, said that Mr. Turner had taken him a little to task for his emphasis on the part played by the workman. He was quite unrepentant. He did not suggest that scientific control should be abandoned or lessened and that of the workman substituted. That was far from his intentions.

In a final word, the chairman said that he endorsed what had been said concerning the necessity for collaboration between technical officers and craftsmen. The latter had different tools from those used in years gone by. They had to be keener to watch things and effect control. The technical people still had a long way to go in order to give them tools which would make their operations more regular and more standardised. As chairman of the Institute's Metallurgical Engineering Committee, he expressed gratitude to the authors of the papers in the symposium.

The report of the Institute of Metals Spring Meeting will be continued in a subsequent issue of "Engineering."

The Institution of Naval Architects (*continued from page* 619)

SHIP AND MODEL RESISTANCE IN TURBULENT FLOW

SUMMARY OF PAPER

The second paper presented at the morning session on April 9, was that of Dr. G. Hughes, of the Ship Division, National Physical Laboratory, under the somewhat ponderous title of " Friction and Form Resistance in Turbulent Flow, and a Proposed Formulation for Use in Model and Ship Correlation."

The work described in the paper was a continuation of that covered by Dr. Hughes's previous paper (*Trans. I.N.A.*, vol. 94, page 287, 1952) on " Frictional Resistance of Smooth Plane Surfaces in Turbulent Flow "; it covered tests with submerged plates and sheets, and with shallow-draught pontoons, extending over a range of Reynolds numbers from 0·03 to 250 million and of length/breadth ratio of the surfaces from nearly zero to 64. The results conformed to a skin-friction formulation represented by a family of lines of specific resistance to a base of Reynolds number, the basic line being for infinite aspect ratio, i.e., two-dimensional flow without edge effect. Some experiments with submerged cylinders were also included; these showed that the effect of transverse curvature was to make the slopes of the friction lines steeper than for plane flow. The range of Reynolds number covered was from well below the normal model range up to values in the small ship range; from which, Dr. Hughes showed, accurate extrapolation was feasible to all ship sizes and speeds, on the basis of proper co-ordination of all the results according to the laws of viscous flow for geometrically similar shapes. The form resistance of hulls obeyed the same law, on a constant percentage basis, within the model range, and, the author claimed, it was a logical conclusion that the same must apply at all values of Reynolds number. The free surface resistance was assumed to obey Froude's law.

It was submitted that the application of the results given in the paper to model and ship work would provide a sound basis for the correlation of model results of all sizes; an accurate method for the prediction of the results for smooth ships from any size of model; a sound basis for the assessment of roughness effects; a means of analysing form resistance and determining the main factors on which it depended; and a means of analysing free surface resistance and determining the main factors on which that also depended. One of the most interesting conclusions from the work described was that the hull resistance of the ideally smooth ship was much less than had been supposed, though it might be that the best possible result would not be achieved on trials without a special covering to the hull, similar to the plastic used on the model tests. If good bonding to the steel surface could be achieved, the problem would be solved, for such a covering would be waterproof, durable and smooth, and would not require any painting.

DISCUSSION

Professor A. M. Robb, in opening the discussion, observed that Dr. Hughes had presented a very attractive diagram showing the analysis of hull resistance into friction, form, and free surface resistance; but, he asked, what justification was there for separating free surface resistance from form resistance, which, as was shown earlier in the paper, was a resistance associated with pressure distribution? Many years ago, Lord Kelvin presented, as the result of purely mathematical considerations, a diagram of a wave pattern which tallied, if not exactly, certainly very closely with the facts, and that wave pattern was due to a travelling pressure point. If Dr. Hughes was not satisfied that the wave pattern was merely the manifestation of a pressure distribution, he should refer to a set of experiments made in the Taylor Model Basin on a cruiser in shallow water, where the experimenter definitely recorded the gradual disappearance of the stern wave system with increasing speed. That disappearance was certainly associated with the dying away of the aft pressure peak, almost certainly due to that phenomenon and separation of flow. Dr. Hughes stated that streamlining implied no separation of flow at any point. If that was the definition of streamlining there was no such thing as a streamlined body, because separation was inevitable in the given circumstances of pressure. In view of the evidence from the cruiser, it was impossible to separate out free surface resistance and frictional resistance. In the section on experiments with submerged cylinders, Dr. Hughes stated that, " instead of a single line for all values of Reynolds number, as would be the case if there were no curvature effect or a constant percentage curvature effect, the results show an effect of transverse curvature decreasing fractionally with increase of Reynolds number; " but they really showed a departure from the effect of geometrical similarity. Dr. Hughes stated the correct principle earlier in the paper, where he said that there was a single line with viscous flow if there was geometrical similarity.

REYNOLDS NUMBER TESTS WITH STRUTS

The Rev. R. T. Shiells said that he was particularly interested in the low range of Reynolds number tests – 70,000 being the lowest – performed by means of struts ½ in., 2 in. and 4 in. long, measured in the direction of motion. Those tests, though outside the normal practical range, formed a valuable addition to the knowledge of the subject. It was a real achievement to obtain consistent values of C_f for $\frac{t}{l} = 0$, in view of the strain on accuracy imposed by having to determine C_f as a small difference between two relatively large quantities. Thus, in the extreme case of the ½-in. strut, C_f had a value of just over 0·01 whereas the total strut resistance ranged from 0·02 to 0·07, according to the thickness. Those relatively deeply immersed struts would experience only viscous resistance, and Dr. Hughes had assumed the resistance of the square-cut edge to be directly proportional to the thickness, and the resistance due to the tapering after end to be proportional to the square of the thickness. The assumption that the resistance of the after end was proportional to the taper slope, he felt, was doubtful, and he would like to know whether it had a sound theoretical basis.

The paper stated that the square leading edges of the struts produced turbulent flow over the complete length, except possibly the first $\frac{1}{10}$ to ¼ in., as deduced by Dr. Hughes from the comparison of his line with the Blasius line. In 1953, when he (Mr. Shiells) gave an account of the determination of the resistance of ½ in. sand strips by measuring experimentally the resistance of a 1½ in. strut in the bare and sanded condition, Dr. Hughes suggested that the result was probably too large, due to the neglect of the turbulent flow on the last ¼ in. of the strut aft of the sand strip. How was it that Dr. Hughes considered that his struts, with leading edges ranging from 0·02 to 0·08 in. wide, produced turbulence, whereas his own, with a machined edge of 0·031 in., apparently did not ? A tentative explanation of that anomaly was that, at low Reynolds numbers, it did not matter numerically whether the flow was laminar or turbulent, since at very low Reynolds numbers the numerical difference in C_f value was negligible. Even in fully turbulent flow, except for a very rough surface, there was always a thin laminar layer. Since both were always present, it would seem that a formula containing a laminar and a turbulent term might well have a theoretical basis. Despite the queries he had raised regarding the lower Reynolds number results, however, he felt that, numerically, they were substantially correct, to judge by the coherence of the results.

SKIN FRICTION LAW

Professor A. D. Young said that, as an aeronautical scientist, he found the paper profoundly interesting, but also disturbing. Perhaps the most disturbing feature was the fact that Dr. Hughes based the skin friction law, which appeared to be so beautifully well founded, at 10 per cent. or more below the Schultz-Grunow or Prandtl-Schlichting laws, which were definitely used for skin friction calculation. As those laws had been used in aeronautical work for a number of years with apparently satisfactory results, he wondered whether Dr. Hughes's basic skin friction law was as well founded as it appeared to be from an initial reading of the paper. The Schultz-Grunow or Prandtl-Schlichting relations were fundamental to all the techniques and methods of direct analysis, drag pitch and form pitch in aircraft work; and if, indeed, there were a 10 per cent. error, it was difficult to believe that it would not have been immediately apparent, in which case the basic Schultz-Grunow or Prandtl-Schlichting laws would have been discarded. In fact, they had calculated the basis of those laws and had checked the drags of wings and bodies in flight and in the wind tunnel by direct and indirect measurements, and they seemed to be well justified. Consequently, while believing that Dr. Hughes had made a profound contribution to the subject, in some respects, particularly at high Reynolds numbers, he might have been somewhat enthusiastic in making deductions from his measurements.

Professor E. V. Telfer said that he must take the side of Dr. Hughes against Professor Young. Those who had 80 years' experience behind them of the use of model experiments and the prediction of ship results could much more forcibly say that they refused to believe that there was anything wrong with Froude, for otherwise they would not have carried on with that law for so long. He had a great respect for the work which Dr. Hughes had given in that paper and his previous one. He (the speaker) had a line of his own. The Telfer extrapolator now lay midway between the Schoenherr and Hughes lines over the whole practical range from the model experiments to the ship, so that whatever compromise might be necessary between them, he was well placed. Dr. Hughes was wrong, however, in presuming that the square edge would give turbulent flow. Over a very wide initial entry zone of the square-edged plate there must be a return flow, and where the turbulent resistance should have been the most intense, it was not the most intense. Plotting the local friction starting from the leading edge would show the effect on the average resistance eventually built up on a flat plate, and he suggested that Dr. Hughes had completely removed that resistance mechanism by having a square edge. The whole question of turbulence induction was in its infancy, and some way must be found to make laminar boundaries not quite so stable as they appeared to be. He assured Dr. Hughes that he would use the paper, and he hoped to represent the whole of the data.

Mr. H. Lackenby, M.Sc., said that he would confine his remarks to the new Hughes skin-friction line which had been awaited with such interest, and would consider its relation to other formulations and the consequences of its adoption. How, he asked, did the new line compare with other well-known formulations, in particular, the Schoenherr line; that was perhaps the best known, though there were others which gave almost the same answer, namely, the

Prandtl-Schlichting and the Schultz-Grunow lines. Above $R_n = 10^6$, which included the range of ship work, the new Hughes line was very nearly parallel to the Schoenherr line, but some 12 per cent. below it. That was an appreciable difference, much more than the differences between the other contesting lines which existed before the new Hughes line. Incidentally, it was 4 per cent. below the Hughes line of 1952. As regards the Schoenherr line, Dr. Hughes explained away the 12 per cent. difference on the ground that Schoenherr disregarded the length/breadth ratio effect or edge effect. That might well be the answer. There were, however, other lines and data in that upper region; the Prandtl-Schlichting line was almost identical with the Schoenherr line, and was developed from fundamental work on pipes. A further development was the Schultz-Grunow line, which involved a very slight adjustment to suit some measurements of local skin friction made on an inset plate in a wind tunnel. There seemed to be no reason to suspect that those measurements were affected by length/breadth ratio or other effects. Then there were the Jones and Williams experiments on a flat plate in the compressed-air tunnel at the N.P.L. Again, those were in the upper region, and there seemed no reason to suspect them. There was also the paper by Landweber to the Society of Naval Architects and Marine Engineers, which boiled down all the available boundary layer investigations; that paper also tended to confirm the upper regions. Thus, even ignoring the Schoenherr line and its supporting data, there was still much evidence that there was no reason to suspect in the higher region. Clearly, somebody was wrong, and the difference was no less than 12 per cent. Before a decision could be reached, a satisfactory explanation must be found for those differences. Opinions were not sufficient; the differences must be scientifically explained. If Dr. Hughes, with his long pontoons, had had a few inset plates and had measured the total resistance on them and had plotted the results against a Reynolds number based on the length from the fore end of the pontoons, he would have got local skin friction. It was a pity that he had not done so; it would have been an excellent check on his line, because, with those measurements of local friction there could be little or no question of edge effect coming in. That was not a new technique; it had been done more than 20 years ago.

FORM EFFECT

Coming to the application to ship model work, he had already remarked that the new line was practically parallel to the Schoenherr line; that was interesting because, if predictions were made in the usual manner, the same answer should be obtained by both the Hughes and the Schoenherr methods. However, Dr. Hughes attempted to take into account the effect of form by taking the extrapolator as a constant percentage higher than the basic line. That led to an increased slope, and in applying it to the 500-ft. ship at a speed of 15 knots, the 16-ft. model gave a prediction of 40 per cent. less than Froude and 20 per cent. less than Schoenherr, which were tremendous differences. The 20 per cent. difference was due almost entirely to the artifice of assuming the form effect on skin friction as being a constant percentage of the plank friction. That was a fairly reasonable assumption, but the evidence adduced for it in the paper was not overwhelming. He was glad that, at the N.P.L., they were going to do something about that by carrying out tests on double models, presumably at higher Reynolds numbers. He would be interested to see whether that constant form effect had really gone up.

Mr. K. C. Barnaby, O.B.E., observed that, while Dr. Hughes's very important experiments had been taken to a higher Reynolds number than had been possible previously, they had to be carried out at aspect ratios that were very far removed from ship practice. If the equivalent breadth for a ship form were taken to be the wetted surface divided by the length, normal ship ratios were only about 5·0. The highest value might be about 10 for a destroyer in the light condition, but that would be very exceptional. Dr. Hughes's longest pontoons had a length/breadth ratio of 64, or more than ten times the average ship ratio. To bring those high ratio results to the basic conditions of $\frac{l}{b} = 0$, a very large correction had to be applied, which might involve some error. For that reason it might seem preferable to consider the new coefficients as fully valid over a rather more limited range, say log $R_n = 6{\cdot}0$ to log $R_n = 8{\cdot}0$. The lower limit would cover the model range. If those values were plotted in the Telfer manner of the inverse cube root, they gave what was effectively a straight line and it was only necessary to swing the Telfer extrapolator through a small angle to obtain virtual coincidence. A rather hasty examination showed a line with the formula $C_f = 0{\cdot}0125 + 0{\cdot}294\ (R)_n^{-\frac{1}{3}}$. The average divergence of that line from Dr. Hughes's experimental points was only about 1 per cent., as compared with about 10 per cent. from the Schoenherr line. That seemed to be rather a striking confirmation of the Telfer formula, with the same negative index of one-third, but slightly adjusted coefficients.

Dr. Hughes, in reply, said that Professor Robb had referred to two points of principle, but, he felt, he had completely mis-read the intention of the paper, which did not claim that the hull could be split into three parts, identifying the amount due to friction, etc. There was no such suggestion. All that had been said was that the total resistance of a body could be compared, first, with the resistance of a plane surface, and, secondly, with the resistance of a three-dimensional body having the same area and length. With regard to curvature, also, he had mis-read the diagram (Fig. 13) which showed the effect of the results of the cylinder tests. Professor Robb said that the three curves did not come together because they were not for geometrically similar bodies. That was agreed; the paper did not say that, because they did not come together, that was evidence of the curvature effect.

Professor Young found the results disturbing, which was not surprising, since he and others in aeronautics had used the Prandtl-Schlichting and Schultz-Grunow lines for some years. In regard to ships, they had been using Froude for 80 years and still did so, and they got results; but that did not prove that the method was necessarily right. Professor Young's criticism in respect of the low Reynolds number range, he thought, was completely unjustified. He suggested that there must be a considerable amount of laminar flow, and probably separation, in those results. If that was the case, a great deal of separation and laminar flow must occur on models when trip wires were used. The thinner plate used in the tests was only 0·02 in. thick, and the trip wires were 0·04 in. in diameter. He did not see why there should be any appreciable amount of separation behind that edge when there was only 0·01 in. projecting into the flow. It was true that they had thicker plates to get the extrapolation to zero, but all the results fitted into the common formulae, and the results did appear to justify that extrapolation, even though the basic principles might not be acceptable to some people. He felt, therefore, that there was no question whatever about these results conforming to a condition of turbulence (not necessarily turbulence right up to the leading edge, but a substantial measure), and he did not see why there should be any question of separation. There were about 60 sets of results, all conforming to a single formulation. That answered to some extent Mr. Shiells's comments on the leading edge plate result.

It was suggested by Mr. Lackenby that, if they had inserted local friction plates in the pontoons, they would get better confirmation, but he did not agree with that. Professor Telfer had remarked that all the results fitted in with his extrapolator. He hoped that Dr. Telfer would afford him a preview of his paper. It seemed quite unnecessary to re-present all the data in the way he advocated in order to prove that point one way or the other. The simplest way was to put Professor Telfer's line on top of his own, which he had done. The hope had been expressed in the paper that some of the double model results might be available in time for the meeting. That had not been possible, but the apparatus was all ready and it was hoped to make the first tests after Easter.

To be continued

THE NATIONAL PHYSICAL LABORATORY

OPEN DAY AND ANNUAL REPORT

Again this year, the publication of the annual report* of the National Physical Laboratory has coincided with the annual open day. The Executive Committee regretted that the staff position had not improved during the year, but hoped that the proposed limited expansion during the next five years might make more staff available. The committee approved that a new research division should combine the present Electronics section with the Control Mechanisms section of the Metrology division. The field of the new division would be the automatic control of experimental, industrial and administrative processes and the development of techniques and equipment for data processing and computation. They also approved that a small group should be set up to investigate the possibilities of applying high-speed mathematical equipment to the problems of large-scale clerical work.

AERODYNAMICS

The high-speed laboratory buildings are complete and work has begun in them. This gives two new wind tunnels and the 11-in. tunnel has again been put into service. Rotary derivatives can be measured on the whirling arm, which can attain a speed of 100 ft. per second. This was being demonstrated on open day, and also the water tunnel giving visual observations of the stalling of swept-back wings. A slit of light illuminates very fine aluminium particles in the water, which give a picture of the flow over a thin section. Air can be introduced to show the position of low pressure areas. Work done during the year on the open-jet tunnels includes the determination of the air flow over the Royal yacht " Britannia " both for smoke removal and for helicopter landing.

ELECTRICITY

During the year, progress was made towards the establishment of a Standard Frequency Service by the introduction of continuous transmission on 2·5, 5 and 10 megacycles with a maintained accuracy to within 2 parts in 100 million. Work continued in the use of electronic devices to replace mechanical alternating current generators. The new surge generator, with a capacity of 3·2 MV and 77kW- seconds has been installed and is now operating. A full

* *National Physical Laboratory: Report for the Year* 1953. H.M. Stationery Office, Kingsway, London, W.C.2. (3*s*.)

description of it was given on page 625 of last week's issue of ENGINEERING.

LIGHT

The various sources of uncertainty in the transmission properties of the optical elements in the Primary Standard of Light were eliminated during the year and new determinations have begun. A high-precision lathe, made by Bryant Symons and Company, Limited, 12 Northumberland-park, Tottenham, London, N.17, has been installed and was on view. It is illustrated in Fig. 1. Threads up to as many as 30,000 per inch can be cut with it, and these will be used in the production of diffraction gratings. (In actual fact, the threads are not "cut" in that no metal is removed, they are "impressed" with a diamond tool.)

The primary helices cut on this lathe are corrected by a tracer lathe using a Merton nut. The latter consists of three small strips of pith which are clamped lightly on the master thread and draw the cutting tool along with them. As they overlap many threads at the same time, minor discrepancies are evened out. Diffraction gratings are being applied to the control of machine tools by using the Moiré fringes that are formed when two gratings are placed one above the other with their axes slightly inclined. If the gratings are moved relatively, the fringes move at an increased rate and can be counted with a photocell. Gratings ruled at 10,000 grooves per inch will enable the fringe-counter to record movements of one ten-thousandth of an inch. A paper on the subject is being prepared.

The infra-red grating monochrometor has now been made. It is a compact instrument designed to record small changes by observation of spectra and for use in controlling chemical processes.

MATHEMATICS

The Pilot ACE computer has been in constant use throughout the year and 32 tracks of the "magnetic drum" memory are now in use. When complete, this will have 128 tracks with 1,024 digits. The new differential analyser has been brought into use and was shown drawing two perspective views of a three-dimensional mathematical curve. These can be used with a stereoscope to give a three-dimensional view of the curve. The machine occupies 4,000 sq. ft. of floor space on two floors of the building.

METALLURGY

The Metallurgy extension was ready for equipment at the end of December last and is now occupied. The ground floor will be used by the refractories section, and the upper floor for X-ray crystallography. A 50-lb. vacuum melting furnace has been installed in the foundry for the production of specimens of pure metal or alloys with closely controlled composition. Castings for the construction of apparatus for the laboratory have also been produced in the foundry.

Work has continued on creep-testing at various temperatures. An extensometer was shown for working at 1,400 deg. C.; it is made in a ceramic material. The creep properties of metal-metal oxide bodies are also being investigated. Work is also being done on the tensile strength of refractories at temperatures in excess of 1,700 deg. C. An oxyacetylene flame from a 3-hole burner is played on to a rod of the material through the length of which is a $\frac{1}{8}$-in. diameter hole. A pyrometer focused down this hole gives the temperature. The rod is held in tension and slowly rotated while the flame is brought closer until fracture occurs.

METROLOGY

Two forms of prototype equipment for the measurement of internal diameters were developed during the year and were on show. One type measures by comparison with a box form built of standard gauges and has a double-ended stylus, contacting each end of a diameter in turn, and controlling the angles of two mirrors which deflect the image seen at the cross wires of a telescope. The second type is a pneumatic comparator for use where several diameters are to be measured or the bore is of considerable length. The instruments have an accuracy of $\pm$ 0·00001 in.

The new primary standard barometer (which can also be used as a manometer) has been completed, and is shown in Fig. 2. It can measure pressures between 0 and 900 mm. of mercury, corresponding approximately to the outer limit of the atmosphere and one mile below sea level. Essentially the instrument consists of a wide bore U-tube and an optical device for measuring the heights of the mercury columns. The arms of the U-tube, which is made of Inconel, are sealed with optically flat glass and are water jacketed, and the whole assembly is supported on anti-vibration mountings. The optical measuring device consists of a pair of telescopes with inclined axes, which can be moved as a unit until the apex of the light beam is on the surface of the mercury, when the projection of an optical grating in the first telescope will be reflected exactly on to a similar grating in the second. When the replica is exact, a balance is reached on a photo-electric bridge and a light-spot galvanometer reads zero. A deflection of 1 cm. on the galvanometer is equivalent to 0·001 mm. in the height of the mercury. The change of setting between a datum pool and the column is measured by reference to line standards of length. The use of such "optical probes" has many applications.

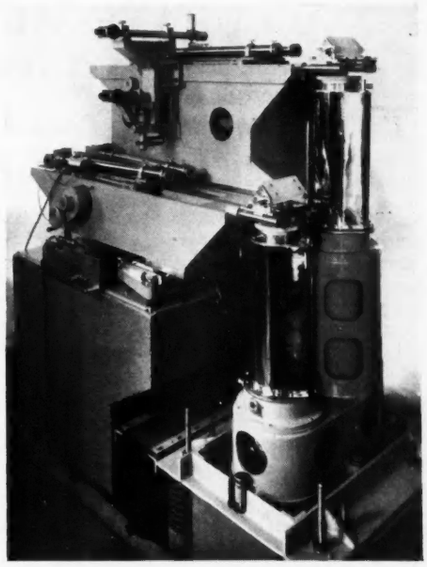

Fig. 2 This barometer for measuring pressures from 0 to 900 mm. of mercury is accurate to 0·001 mm.

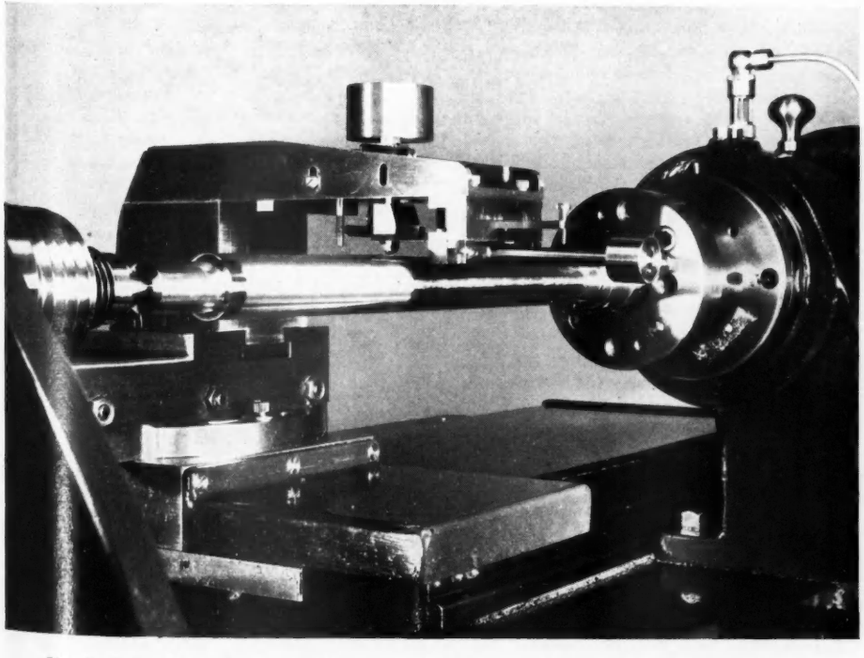

Fig. 1 Lathe for cutting 30,000 threads per inch in the production of diffraction gratings.

PHYSICS

In the Physics division heats of combustion of a number of fine materials were measured, and work in low temperature fields was stimulated by the possession of the Collins helium cryostat. The research on the equal-loudness curves of the human ear is nearing completion. A 50-ton proving ring was exhibited, fitted with a fiducial indicator instead of a vibrating reed.

An ultra-sonic flaw detector was being demonstrated, which is useful when it is not convenient to machine more than a small part of the surface. The beam can be swung electronically (by using a delay line to change the direction of the wave front) so that the greater part of a specimen can be surveyed without moving the head. The model shown had five positions, 8 deg. apart, which, as the beam had a 4-deg. lobe, gave good coverage of the specimen.

SHIPS

During 1953, attention has been given to yacht design. A special dynamometer has been developed to act as the force of the wind, and the model heels and yaws when in motion. A new test section has been built in the water tunnel for propeller cavitation work and the instrumentation modified. The project for a new 1,300 ft. testing tank at a cost of £2 million has been approved and it is hoped it will be finished by 1958.

ACCURATE ALIGNMENT OVER LONG DISTANCES*

INTERFEROMETRY ENSURES 0·0005 IN. OVER 180 FT.

By P. W. Harrison, B.SC.(ENG.), A.M.I.MECH.E., A.C.G.I.

In 1949 an article† by A. C. S. van Heel described some practical applications of a new precision-alignment method suitable for use by engineers, surveyors, and others engaged upon alignment over long distances. As the technique promised to provide a greater accuracy at long ranges than other methods currently used, the National Physical Laboratory carried out its own investigation into the method with a view to the development of an apparatus embodying the principle.

OPTICAL PRINCIPLE EMPLOYED

For those unfamiliar with the van Heel method a brief description of the theory underlying it is included here. It was first suggested by a classical experiment undertaken by Young (1773-1829) in which he allowed rays from the sun to pass through a small hole A, as in Fig. 1, and then through two small holes B and C in a second screen, the light being received on a third screen at D. Young observed that interference bands were formed in the region XY.

According to the wave theory of light, holes B and C act as coherent light sources; provided that the holes are equi-distant and sufficiently removed from A, the approximately plane wavefront at B will be in phase with that at C as they both emanate from the same source. For white light the waves emerging from B and C either interfere or superimpose to form a fringe pattern, as shown in Fig. 2. The typical fringe pattern is symmetrical about a central band of white light flanked on either side by two dark bands, which will be referred to as the " setting lines." These bands are orange-red on the inner edge graduating through deep purple to blue on the outer edge. The rest of the pattern is composed of multi-coloured bands substantially equal in width, the brightness rapidly diminishing as the distance from the pattern centre increases. The substitution of light of a particular wavelength produces a series of dark and bright bands.

It will be appreciated from the above that the fringe pattern formed will be symmetrical about an axis passing through the middle of the single hole and the mid-point of the double hole, providing the plane of the holes is reasonably square to the axis. The pattern will therefore form a ready means of setting a third point on this axis, providing the brightness and colour intensity of the pattern can be maintained at appreciable distances from the double hole.

OPTICAL AND MECHANICAL DESIGN

At the outset an attempt was made to reproduce the apparatus described by van Heel, who replaced the holes by single and double slits. The N.P.L. experimental arrangement is shown diagrammatically in Fig. 3 and consisted of three units. The first of these contained a light source, a collimating lens to provide substantially parallel light, and a single slit, the second a double slit and the third an eyepiece with a micrometer-controlled graticule. For various reasons the resulting fringes were disappointingly weak and blurred. It was therefore decided that, while adhering to the basic principles of the technique, a comprehensive series of tests should be undertaken in which the various factors likely to influence the performance could be varied at will.

These factors included: (i) design of slits; (ii) type of light source; (iii) slit proportions; (iv) selection of the setting datum in the fringe field and the appropriate design of graticule; (v) magnification of eyepiece; (vi) the effect upon the fringe pattern of the disposition of the component parts; and (vii) effect of external illumination.

The results of these tests enabled conclusions to be reached regarding the preferred form of the component parts of an alignment set, the performance that might be expected of them, and possible applications for such equipment.

The three units which comprise the prototype alignment set are shown in Fig. 4, and are, from left to right, the single-slit unit, the double-slit unit, and the micrometer eyepiece. All consist of accurately ground hardened-steel cylinders of the same diameter, recessed at one end to receive very closely-fitting spigot pieces upon which the slits and micrometer eyepiece are mounted. It is intended that, in use, the parts to be aligned should be designed to receive these units, either by their being entered into a bore, or by being held in a V-block or angle plate. It follows, therefore, that, as it is the slits and graticule which are brought into line by observance of the fringe pattern, these features must be capable of being set in a known relationship to their respective cylindrical bodies, and that the most convenient relationship is with them set symmetrically about the axis of the body.

In order to make this setting in the two slit units with a high degree of precision, a fine slit-positioning adjustment has been used. Reference to Fig. 5 will show that the slits are formed by steel strips *a* mounted in a recess on the underside of a parallelogram-shaped block *b*; the block is held in contact with the inclined face *c*, machined on the spigot piece, by the spring *d*. The position of block *b* along face *c* may be adjusted by two opposed grub screws.

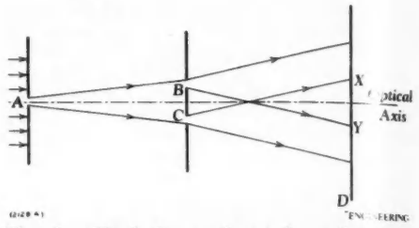

Fig. 1 Classical experiment in optics which allows light from a distant source, the sun, to pass first through a small hole A, then through two more holes B and C. Interference bands are formed in the region XY.

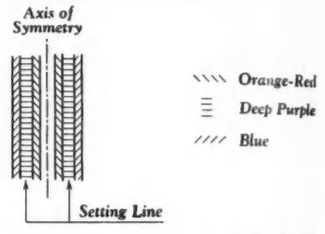

Fig. 2 The interference bands which are formed at XY in Fig. 1 give rise to fringe patterns of the type shown here.

Cover plate *f*, shown removed, closes the box-like enclosure for block *b*. Because face *c* lies at a small angle with respect to the slit, small adjustments of the grub screws will produce very small lateral displacements of the slit. By precise construction of the component parts of the unit, the slit, when set for lateral position, is not appreciably off-centre along its length.

When item (ii), the light source, was considered, lamps of various power and type were tried. The lamp finally embodied in the single-slit unit is a 24-watt close-coiled filament lamp having the filament set parallel to the slit and located at the principal focus of the collimating lens. It had been hoped that mercury-vapour arc lamps (both high-pressure and laboratory types) in conjunction with the appropriate filters, producing near-monochromatic light, would provide sharper lines, but the resulting spectra field was not improved in definition as had been hoped; rather, in fact, the reverse.

Under item (iii), slit proportions, it soon became apparent that, to maintain adequate

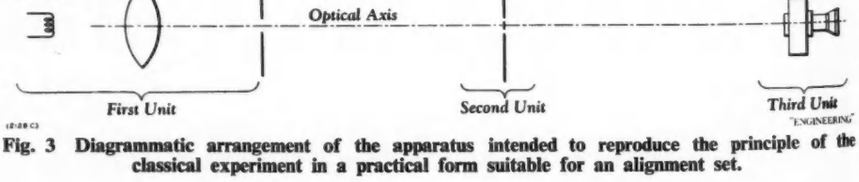

Fig. 3 Diagrammatic arrangement of the apparatus intended to reproduce the principle of the classical experiment in a practical form suitable for an alignment set.

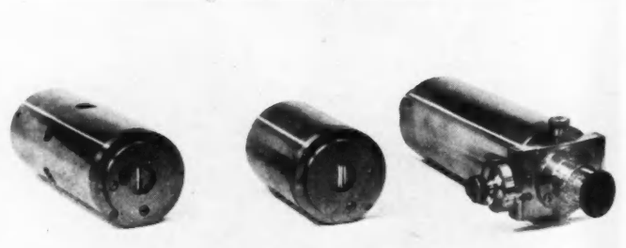

Fig. 4 The three units of the prototype alignment set. They are, from left to right, the single-slit unit, the double-slit unit, and the micrometer eyepiece.

* Communication from the National Physical Laboratory.

† van Heel, A. G. S., " Some Practical Applications of a Precision Alignment Method." *Appl. Sci. Res. B.I.*, page 306, 1949.

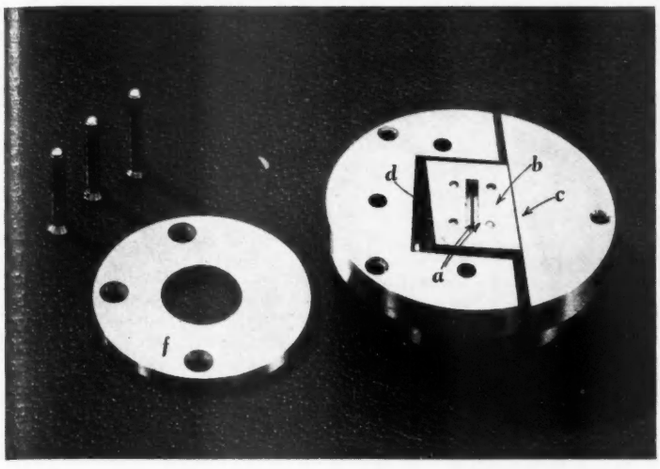

Fig. 5 Locating unit for the slits. The high accuracy with which the slits can be located enables the middle of three units to be set on the line defined by the other two to within ± 0·0003 in. when the extreme units are up to 120 ft. apart.

colour intensity of the fringe pattern over a working range up to 200 ft. (61 m.), it would be necessary to have two sets of slits of different proportions, and it was largely the need to exchange slit assemblies without disturbing their setting in relation to their body axes that led to the adoption of the closely-fitting spigots.

In the early N.P.L. experiments attempts were made to set on the centre of each " setting line " in turn, using, first, a cross-wire graticule and subsequently a vertical hairline in the eyepiece. It was found that in both cases this led to appreciable variation between individual observers' values for the mean reading corresponding to the pattern centre. It was also found more satisfactory to make a single setting, by using a graticule comprising a single bar whose width nearly obscured the central band of light, leaving a crisp orange band on either side. A small displacement of this type of graticule with respect to the centre of the pattern produced a marked out-of-balance appearance of the bordering orange bands; this appreciably increased the sensitivity of setting in comparison with the previous technique which conformed to the method described by van Heel. The central setting, which was to be preferred for these reasons, was satisfactorily achieved for a fixed spacing of the double-slit unit and the eyepiece.

However, it is a feature of the fringe pattern that it broadens or narrows with changes in separation of these two units, and consequently the optimum width of the graticule bar is a variable quantity. The design shown in the illustration, Fig. 6, was therefore adopted in order to provide this optimum width with a single graticule bar. The micrometer unit is shown with its cover removed to expose the graticule-carrying slide, which is traversed by the micrometer screw, the slide being continuously biased to the left by the springs. The position of the graticule bar in relation to the slideways is read upon the scale inscribed on the cover, and the drum, which indicate whole revolutions of displacement, and subdivisions of a $\frac{1}{50}$th part of a revolution respectively. Each drum division is equivalent to a movement of 0·0005 in. (0·013 mm.). The graticule bar is a hardened-steel rod which may be rotated about a vertical axis in close-fitting bearings in the slide. Over its central portion it has been ground away to an accurate diamond-section, so that, by rotating it, its effective width, as seen through the eyepiece, can be varied.

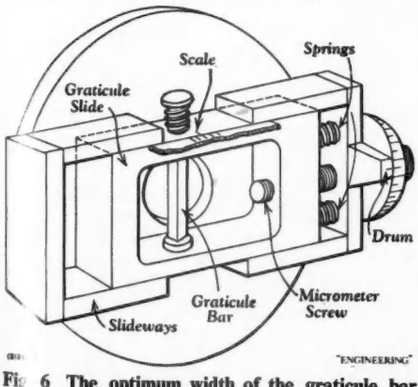

Fig. 6 The optimum width of the graticule bar varies with the distance between the units of the alignment set. This unit enables the optimum width to be provided with a single graticule bar.

The setting of the slits and graticule bar on the axes of their respective cylinders was made on a universal measuring machine, fitted with a microscope, by observation of the boundary lines on the cylinders, slits and graticule bar.

With regard to (v), over-magnification of the pattern reduces its crispness of colour and the sensitivity of setting. Normally, a 7x Ramsden eyepiece is suitable for the small and medium ranges, an eyepiece of lower magnification being used with benefit over ranges in the region 100 ft. to 200 ft. (30 m. to 61 m.).

The characteristic broadening of the fringe pattern with increased separation of the units has been referred to earlier. Because of the reduced crispness of the pattern which results, it has been found advantageous for the apparatus to be arranged so that the double slit lies closer to the eyepiece than to the single slit, if the intermediate of the three points to be aligned is very appreciably displaced from the mid-position. It further appears that the separation between the single and double slit unit should not be reduced to much less than 10 ft. (3 m.) as the balanced appearance of the pattern then becomes unduly sensitive to any error in form of the double slits. The smallest width of fringe pattern on which settings can be made is determined by the minimum effective width of the graticule, and it has been found in practice that on this account the separation of the double slit and eyepiece should not be reduced below about 6 ft. (1·8 m.).

The method can be used in lamplight or dull daylight in the manner described. In normal daylight precautions have to be taken to prevent strong light entering the eyepiece; this is achieved in the alignment set by substituting a pinhole eyepiece for the Ramsden eyepiece. In brilliant daylight, additional precautions are necessary, and take the form of a light-alloy tube extending forward from the body of the micrometer eyepiece. The tube, some 3 ft. long (1 m.), is blackened on the inside and, by cutting the end in a plane inclined at 30 deg. to the axis and turning the longer side towards the light, it affords a further measure of shielding. It is used in association with a blackened cowl on the double-slit unit, the cowl being of such proportions that it covers the field of view of the eyepiece when the shield tube is in position.

PERFORMANCE

When the alignment set had been constructed along these lines, attention was turned to suitable methods by which its performance could be checked, in respect both of accuracy of repetition, and accuracy of alignment. As a preliminary, therefore, observations were made to check the accuracy of repetition and the agreement possible between different observers. The results of these checks were sufficiently encouraging for them to be followed by a self-checking test designed to reveal the accuracy with which the apparatus could estimate the misalignment of three points. Four equally-spaced V-blocks (say 1, 2, 3 and 4) were brought approximately into line by an alignment telescope and collimator unit. The units of the interferometric set were positioned in blocks 1, 2 and 3 and a micrometer observation made of their misalignment: the procedure was repeated at 1, 2 and 4, at 1, 3 and 4 and at 2, 3 and 4. From all these observations three values may be deduced for the departure of 3 from the line joining 1 and 4. The lack of agreement between these values has been accepted as a measure of the accuracy of optical alignment attainable with this equipment.

It was concluded that an accuracy of alignment of a middle point with respect to a line joining two points spaced up to 60 ft. (18 m.) apart, could be easily achieved to within ± 0·0003 in. (± 0·0076 mm.). Under optimum atmospheric conditions in which the brightness, depth of colour and definition of the pattern were sufficiently good, this order of accuracy could be obtained up to 120 ft. (37 m.), falling to ± 0·0005 in. (± 0·013 mm.) at 180 ft. (55 m.). However, more often than not, difficulty was experienced over the larger ranges due to air disturbances along the optical path causing the fringe pattern to flicker. Conditions indoors are dependent upon the size and shape of the room, and the distribution of the heating system. For example, in a large room with heating pipes round the walls the accuracy over a 100-ft. (30-m.) range might fall at least to ± 0·001 in. (± 0·025 mm.).

It may be added here that, to obtain the maximum accuracy when the observer is interested in absolute alignment, it is desirable that two sets of readings should be taken, all units being rotated through 180 deg. between sets. This will eliminate the effect of small residual errors in certain features of the equipment, such as the slit positions. This procedure is not necessary when the observer is interested only in variation in the alignment of three points.

APPLICATIONS

Finally, an alignment set of this type has numerous specialised applications; for example, the alignment of long rail sections such as those employed on model ship testing tanks, in addition to the more obvious uses in large constructional work and industries in which large jigs have to be aligned during their assembly. Surfaces can be explored for straightness of a generator by moving one of the three units along the optical axis, the other two units remaining stationary. In fact, the cylindrical form of these units permits them to be rotated to measure misalignment in any plane containing the optical axis.

Acknowledgments are made for help received from Mrs. J. G. Wood for suggesting the four V-block method of assessing performance, and to Mr. J. Wilson of the Metrology Workshop who constructed the equipment.

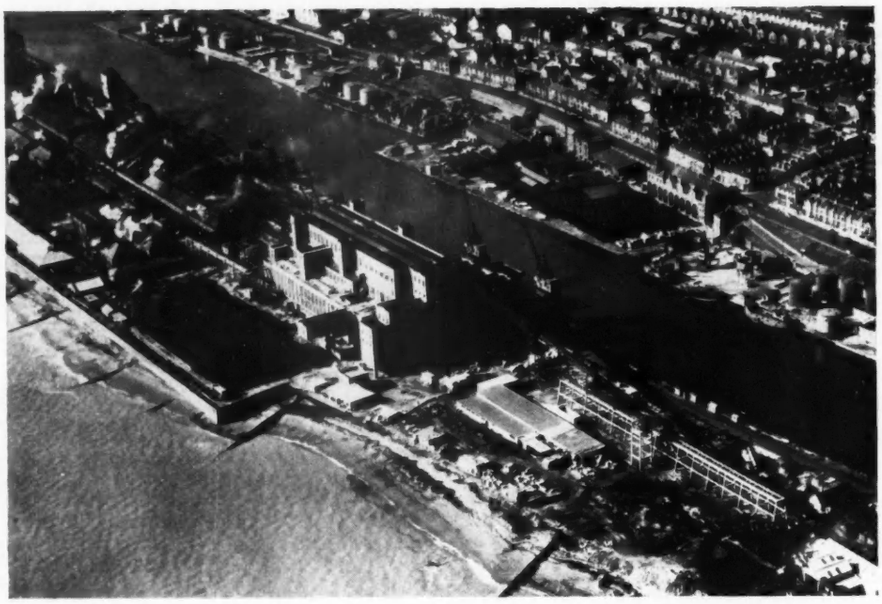

Fig. 1 Aerial view of Portslade gasworks, looking north-west. The original horizontal-retort plant on the left is to be closed down. Colliers up to 2,000 tons capacity will be able to lie alongside.

VERTICAL-RETORT GAS PLANT

A CENTRAL WORKS FOR SUSSEX

The gasworks opened on May 3 by the Duke of Norfolk, at Portslade, Sussex, is intended to be a central station for a large area of the county. It is considered that a single large station of modern design will be more efficient and economical than several small ones built some years ago. The new plant will eventually replace the existing one at Portslade. Brighton, Hove, Worthing, Littlehampton and Arundel are already being supplied from Portslade, and mains are being laid to Petworth, Billingshurst, Haywards Heath, Uckfield and Seaford. Main contractors for the work were the Woodall-Duckham Vertical Retort and Oven Construction Company, Limited, 63/77 Brompton-road, London, S.W.3.

Viewed from the south-east, the works appears as in Fig. 1. The sea lies in front of it, while behind is Aldrington Basin, the eastern arm of Shoreham harbour. Ships lying in the Basin are unloaded by the two Stothert and Pitt cranes which feed the hopper between them. At present, only ships up to 1,400 tons capacity can be used, but the harbour entrance is being enlarged and the channel dredged so that ships up to 2,000 tons capacity can enter. Lying on a spit of land between the sea and what was once part of the river channel, the foundations of the building presented some difficulties. The subsoil consists of made-up ground, beach and rock-chalk. There is also a stratum of lignite which is very resistant to penetration. Moreover, at one time it is believed that the river mouth was at the centre of the site, so conditions over the site area alone differ widely. When the ground was being excavated for the coal and coke elevating plant, water was encountered at 7 ft., 9 ft. above the designed bottom of the excavation. The new buildings are supported on Vibro piles, some being 70 ft. long with a designed maximum load on each of 55 tons. To accommodate the colliers which will supply the works, the wharf has been extended for 809 ft.

As the station occupies a prominent position on the sea-front, it was laid down that its appearance should be as pleasing as possible and that atmospheric pollution should be kept to a minimum. These considerations influenced the choice towards vertical retorts and it was agreed that the old horizontal plant, which can be seen on the left of Fig. 1, should be closed down as soon as possible. The main building, of which two-thirds are complete, is a steel-framed structure panelled with "golden-faced" Southwater bricks. Special attention has been paid within the works to reducing dust and smoke to a minimum and to providing clean, cool air inside the retort house.

INCOMING COAL

The two unloading cranes are electrically operated and each has a maximum rated capacity of 240 tons per hour when dealing with graded coal or of 180 tons per hour when run-of-mine coal is being handled. They are of the level luffing balanced-jib grabbing type with each motion operated from a separate motor. The revolving portion is mounted on a gantry, s may be seen in Fig. 1, and the maximum j radius is 70 ft. The working load at this radi is 8¼ tons (including the grab). The grabs us are Priestman twin-rope self-dumping models f the scraper-digger type. They can handle ru of-mine coal up to 18-in. cube.

These cranes have only a short traverse alo g the wharf and their power-supply cables are unrolled from drums as they move outwards from the hopper. The latter, of reinforced concrete, has a capacity of 200 tons of coal. Vibratory feeders pass the coal on to two conveyor belts from which it can be delivered either to the storage hoppers above the retorts by way of a bucket chain or to the open storage dump on the south side of the station. Weighing and recording are carried out automatically, and at predetermined intervals an automatic device collects samples of the coal passing to the hoppers. The open store, which can be seen on the left of the works in Fig. 1, has a capacity of about 20,000 tons. The discharge conveyors run in the projecting gantry and the coal is spread by a drag-scraper. For reclamation, the scraper bucket is reversed and coal is dragged to a collecting hopper below the gantry from which conveyors take it back to the main incoming conveyors and the bucket chains carry it to the distributing conveyors above the retort hoppers. These hoppers can be seen from below in Fig. 2, which is a view looking along the top charging platform. If necessary, the coal is passed through British Jeffrey-Diamond single-roll crushers before being elevated to the hoppers.

OUTGOING COKE

Beneath each bench of retorts there is a hand-propelled travelling chute which receives the coke from the water-sealed dischargers and feeds it to one of two conveyors. Fig. 3 shows the bottoms of some of the retorts with these conveyors passing below them. The coke is cooled before discharge by injecting water or steam. Gravity bucket conveyors take the coke up to the screening plant, which is the nearest part of the building as seen in Fig. 1. The final conveyors deliver the coke to the screens, or, alternatively, it can be delivered unscreened to open storage, the conveyor system for which is in the right foreground of Fig. 1; 4,000 tons can be stored there.

There are four complete sets of screening equipment, each comprising a scalping screen with primary and secondary grading screens. There are also four coke-cutting machines. The screening equipment was supplied by Pegson, Limited, Coalville, Leicestershire, and has a total capacity of 200 tons per hour. To avoid

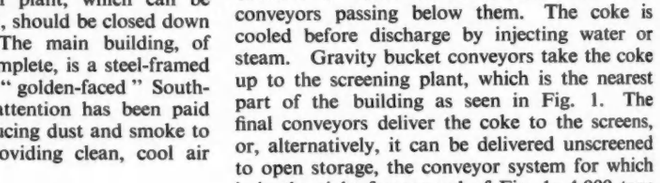

Fig. 2 The retort charging platform. On the left are the hoppers which feed the retorts. The charging is hand controlled. Gas off-take pipes can be seen leading from the retorts.

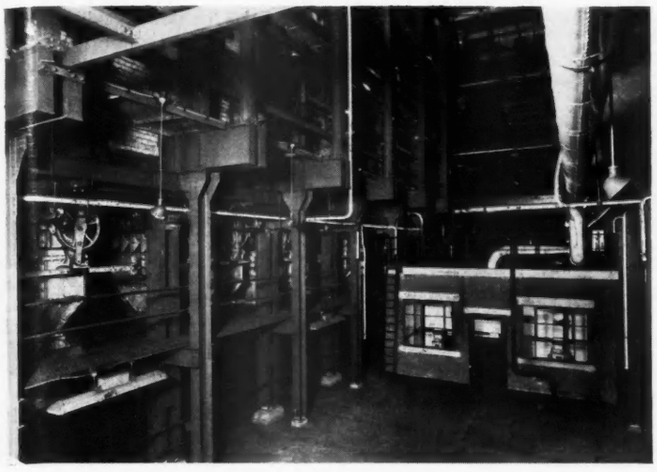

Fig. 3 Coke extractors at the bottom of the retorts. A mobile chute guides the cooled coke on to the conveyor belts which run in the channel below. The closed room houses the liquor circulating pumps.

vibration, the scalping and primary screens are mounted on rubber blocks, and all the vibrating units are totally enclosed for protection against dust. The graded coke is stored in bunkers from which it passes over screens to remove the breeze before being fed by chute to either the lorry-loading side or to the weighing and bagging machines. The storage bunkers have a capacity of 1,200 tons and the coke is graded into four sizes. Coke required for the producers and for the retorts when starting up or after scurfing is delivered from the storage bins to the appropriate hoppers by belt and gravity bucket conveyors.

VERTICAL RETORTS

Each of the three sections of the plant will have 56 continuous vertical Woodall-Duckham retorts arranged in two parallel benches. The total daily output of the three sections will be approximately 17,500,000 cub. ft. of gas with a calorific value of 505 B.Th.U. per cubic foot. This allows for the extraction of two gallons of benzole for every ton of coal carbonised. Each section will carbonise about 420 tons per day. Coal discharge from the hoppers to the retorts is hand controlled.

Each retort is under independent heating control, being provided with separate producer gas, secondary-air and waste flue gas dampers. The lambent heating system is employed and a single damper controls the producer gas to each side of the retort. The control gear for one of these dampers is in the foreground in Fig. 4. The secondary air, which can be admitted at four levels, is preheated by circulation around the seating castings and supporting steelwork of the retorts, and again when passing to the heating flues after admission. The use of mechanical producers and dust extraction plant keeps the atmosphere within the retort house comparatively dust-free, which in turn means clean secondary air and heating flues. Standard Woodall-Duckham coke extractors with water-sealed dischargers are used and the gas off-takes are sprayed with ammoniacal liquor. In Fig. 2 the off-takes can be seen leading from the retorts on the left.

The crude gas collected from the retorts is taken by mains to an Askania regulator. In addition to those in the off-takes, there are ammoniacal sprays in the collecting mains and crude gas mains; the liquor is circulated by direct-coupled electrically-driven centrifugal pumps. These are housed in the brick building on the right of Fig. 3 and each can handle 4,500 gallons per hour, the requirement of one retort bench. There is a third pump provided for every two benches as a standby. Each bench has its tar and liquor circulating and separating tank. Two 36-in. steel overhead mains take the gas to the exhausters and purification plant. They are those which served the old plant.

PRODUCERS AND WASTE-HEAT BOILERS

The retorts are heated by producer gas generated in Humphreys and Glasgow mechanical producers. There is one of these for each bench and there will be four spares, making ten in all. They are placed at ground floor level on the outer side of the benches; the charging cone of one is shown on the left in Fig. 4. The coke is brought by the travelling hopper which can be seen in the background and which runs on the overhead rail. The hopper is loaded, under hand control, from the chute which can be seen projecting from the roof; all coke to the producers is weighed and automatically recorded. The weight recorder is beyond and to the right of the operator in the illustration. Wet ash from the producers is collected in skips which are wheeled to the two ash-hoists and the ash is delivered to a receiving hopper.

Each producer is fitted with an annular waste-heat boiler producing steam at 20 lb. per square inch, which is used for steaming the retorts and saturating the producer blast. Any excess is used for heating boiler feed water. A cyclone dust extractor is fitted to each producer.

Each of the ten waste-heat boilers (again there are four spares) is rated to produce 11,000 lb. of steam per hour at a pressure of 150 lb. per square inch. They are of the horizontal multi-tubular fire-tube type and are fitted with Sirocco induced-draught fans driven by non-condensing steam turbines Superheaters are fitted to the inlet flues. One of these boilers is visible on the right in Fig. 4. Should the waste gases not be sufficient, there is provision for burning producer gas.

* * *

AIDS TO HEARING

Compactness of Transistors

An exhibition arranged by Amplivox, Limited, at 47 New Bond-street, London, W.1, was opened on May 11 by Mr. Peter Dimmock of the British Broadcasting Corporation. The exhibition shows the development of hearing aids during the last 150 years, finishing with the firm's latest model which is built into the frames of a pair of spectacles. The exhibition is open from 10 a.m. to 8 p.m. daily until May 22. In addition to aids for those who are hard of hearing, a range of earphones and microphones for flying personnel and other specific occupations is being shown.

One of the points emphasised in the exhibition is the unobtrusiveness of modern aids. In the case of the spectacle aid mentioned above, the bulge in the frames which contains the apparatus can be placed at the end where it would be largely covered by a lady's hair. In any case, the enlargement is so slight owing to the use of a transistor circuit, as to be quite acceptable. In an alternative model where the microphone and circuitry are in a standard case, the cord connecting them to the earpiece has been made the cord on which a necklace is threaded.

These hearing aids are claimed to be the first commercial application of the transistor in this country. The operating economy can be gauged by the fact that the set which uses transistors throughout will operate continuously for a week on two threepenny torch batteries. The model which uses a transistor in the output stage only requires renewal of the low-tension battery after 80 hours use and of the high-tension after 1,000 hours. All the miniature parts used in these aids have had to be developed by the manufacturers for this particular application.

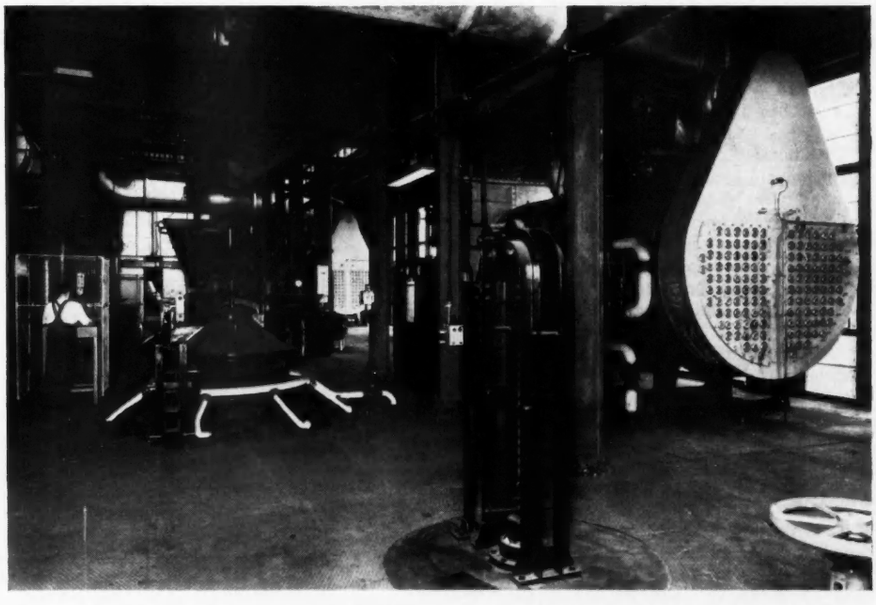

Fig. 4 Producer charging apparatus on the left and a waste-heat boiler on the right. The travelling coke hopper for the producers can be seen in the background. The weight recorder is beyond the operator.

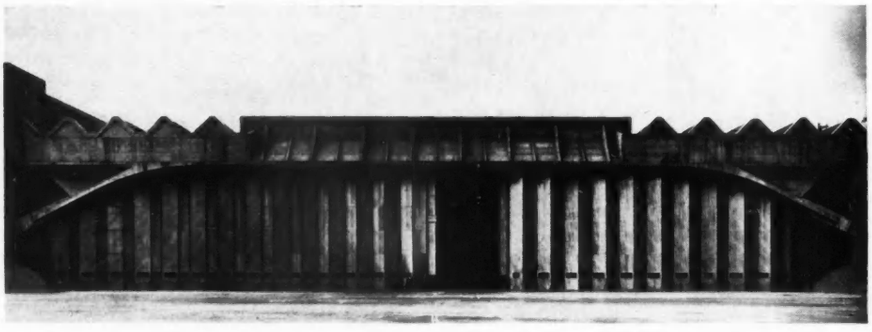

Fig. 1 Templex doors of B.O.A.C. maintenance hangar. The driving motor for each half door, which is cable-operated, is contained in the centre mullion.

HANGAR DOORS OF ALUMINIUM ALLOY

TEMPLEX FOLDING AND SLIDING DOORS AT LONDON AIRPORT

The first of four pairs of aluminium-alloy hangar doors for the new B.O.A.C. maintenance hangars at London Airport has been installed recently and is now in working order. Known as Templex folding and sliding doors, they were designed specifically for the B.O.A.C. hangars by Mr. J. E. Temple, consulting engineer, The Studio, 9A Seymour-walk, London, S.W.10, and were constructed and erected by Head Wrightson Aluminium, Limited, Thornaby-on-Tees, Yorkshire, under sub-contract to the main contractors for the engineering base building, W. and C. French, Limited, 50 Epping New-road, Buckhurst Hill, Essex. This unconventional reinforced-concrete building, it may be recalled, was designed by Sir Owen Williams and Partners.

Each door opening is 46 ft. high and 300 ft. long and, as may be seen in Fig. 1, the doors are in two halves, folding and sliding back from the centre. They can be opened at a rate of 100 ft. per minute. When fully open, each half door folds into a pylon recess so that there is unimpeded access over the whole length of the building.

Each half door comprises a series of vertical pillars mounted on head and base trolleys running on guide tracks. The folding door leaves are hinged together in pairs, each pair of leaves in turn being hinged to the adjacent pillars, by which they are carried.

The outermost pillars, known respectively as the pylon mullion (situated at the end adjacent to the pylon recess) and the power mullion (adjacent to the opening), are held vertical under all conditions by separate pairs of rectification cables. In the power mullion, which houses the driving gear, the rectification cables, driven by a pulley mechanism, also serve to open or close the doors. The inner pillars are maintained parallel and vertical by a system of folding steel links as may be seen in Fig. 4, which shows the doors from within the hangar.

Other than the mild-steel top and bottom runners, draught-excluding flaps, the parallel-motion linkage, fittings, etc., the doors, which have been designed to withstand a uniformly distributed normal wind pressure of 25 lb. per square foot over the whole surface, are made from aluminium alloy. This material was selected primarily for its lightness, combined with the necessary strength and stiffness. The resulting reduced bearing loads and inertia forces permit lighter operating mechanisms to be installed. A 4-h.p. electric motor is sufficient to operate each half door.

The alloys chosen – Noral 51 S.W.P. (B.S. 1476: HE.10) for the sections, supplied by the Northern Aluminium Company, Limited ; B.A. 60 (B.S. 1470: NS.3) for the Rigidal Mansard sheets, supplied by the British Aluminium Company, Limited; and aluminium rivets to B.S. 1473: NR.6-M, supplied by J. Stone and Company (Deptford), Limited – have been developed for use in building work and have an excellent resistance to atmospheric attack, normally requiring no painting. Little maintenance work on the door structures is therefore likely to be required. The doors of the hangars are double-skinned with a layer of Fibreglass insulation between them. Heat losses should therefore be reduced to a minimum.

CABLE-OPERATED DOORS ELECTRICALLY DRIVEN

The way in which the wire-rope cables are arranged to open and close the doors may be understood from Fig. 2, which represents a left-hand half-door from outside the hangar. The upper operating cable is anchored at the top left-hand end of the hangar, passes over guide pulleys at the top of the pillars and in the power mullion, whence it is brought down and taken for three complete turns round the flange of one of twin driving pulleys, thence over a guide pulley at the base of the power mullion to an anchorage at the centre of the bottom of the door opening. The lower operating cable, similarly, is anchored at the bottom left-hand end of the hangar and at the centre of the top of the door opening, and passes over the other driving pulley. Rotation of the twin driving pulleys thus causes the power mullion to be hauled across the door opening in one direction or the other, the arrangement of the cables being such that the mullion remains vertical.

When the doors are being extended across the door opening to close it, the heavy tensile force is transmitted from pillar to pillar by the traction links which can be seen in Fig. 4. During retraction, the force is transmitted from pillar to pillar by direct contact of the head and base trolleys.

As already mentioned, the upper cable is supported on pulleys mounted at the top of the head trolleys on the pillars. To prevent the cable from sagging when the doors are wide open, turnstile brackets are employed, as shown in Fig. 3, which allow the pillar heads to pass freely in either direction.

The twin driving pulleys embody a differential mechanism. Normally they rotate as a solid unit, but should the operating cables creep along the groove, the differential allows relative motion to occur between the two pulleys, thus preventing excessive tension and stretching.

The whole of the electrical gear, power-unit, accessories and wiring is fully flameproof. The supply cables are carried across the upper ends of the pillars to the power mullions, and thence down through the interior of the latter to the power units at the lower end. As the door moves across the track, in opening or closing, a considerable amount of slack must be drawn in or paid out. This is effected by taking the electrical supply cable round two almost frictionless multi-sheave blocks arranged in the power mullion, as indicated in Fig. 2. The upper block is fixed and the heavy lower block is able to traverse vertically between guides up and down through almost the whole depth of the hollow power mullion. Thus the slack of cable is drawn in and paid out automatically by virtue of the weight of the lower block. The electricity-supply cable used is specially designed to withstand the slight tension imposed on it by the weight of the block.

As in the case of the various trolleys and guide pulleys, each of which is a complete self-contained assembly designed to be easily removed and replaced as a complete unit, so the power and transmission unit assembly is a complete self-contained unit arranged to be easily removed and replaced in its housing in the lower part of the power mullion.

The power and transmission unit comprises

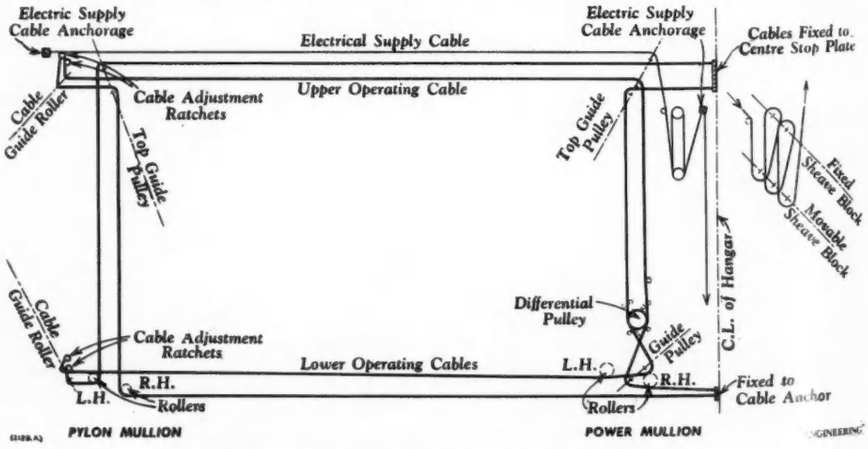

Fig. 2 Arrangement of drive cables and pulleys.

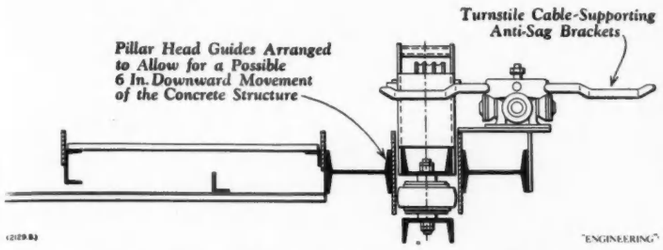
Turnstile Cable-Supporting Anti-Sag Brackets
Pillar Head Guides Arranged to Allow for a Possible 6 In. Downward Movement of the Concrete Structure
"ENGINEERING"

Fig. 3 Detail of pillar head trolley and turnstile bracket. The latter supports the operating cable when the doors are opened, but allows free passage of the pillars as the doors are closed.

motor, speed-reducing gear, electromagnetic brake, centrifugal clutch limiting the torque output from the motor and differential driving pulleys. Emergency hand operation is provided for in case of failure of the power supply. Should any one of the wicket doors be opened while the main doors are in operation, the power supply to the motors is automatically cut off and it is not then possible to actuate the main doors until the wicket door has been closed. The motor is also inoperative if the main doors are locked at the centre. Limit switches automatically cut the motors out when the doors reach the end of their travel; an additional limit switch stops the motion at the entrance to the pylon recess. The folded half door can only be housed in the recess by operating an inching switch from a position in which it is possible to see that the recess is clear of obstruction.

CONSTRUCTING THE DOORS

The construction of the doors called for a complete shop layout and a rather different approach from that normally associated with an aluminium structure. Each leaf and pillar carries five sets of pintle hinges in its length, and while a small degree of adjustment was available in the vertical position, it was imperative that true alignment should be maintained between pillar and leaf in order to erect the doors and for them to function correctly. It will be appreciated that hanging a door leaf with a single hinge at the top and bottom presents no difficulty, but that hanging a leaf with five sets of hinges operating on push-fit pins calls for accurate alignment in order that they will each engage at the same time.

The main fabricated units of the doors were as follow: 104 pillars (i.e., 13 in each half door) built up from two 10 in. by 3 in. channels having an 11 in. by $\frac{5}{16}$ in. flange plate on one side, and a specially shaped extrusion on the other. The stem of the special extrusion carried the hinges and was designed to give additional stiffness to the pillar. Fig. 5 shows a cross-section through a pair of leaves and the adjacent pillar.

The pillars were assembled on the tack-bolting principle, and every hole was reamed and slightly countersunk before riveting. To ensure straightness, stitch-riveting was employed on the pillars and finally a riveting sequence was evolved giving minimum distortion. Squeeze-riveting was employed, the formed head being of the North American cone type. A roller conveyor was laid down at the squeeze-riveting machine, and by keeping the machine stationary and moving the pillars on the conveyor, riveting times were kept to a minimum. The rivets were of $\frac{3}{4}$ in. diameter, and were clinched hot. Rivet-heating was carried out in an electric muffle furnace with automatic temperature control. The furnace was stationed as close as possible to the work and sand trays were employed to maintain the temperature while the rivets were transported.

In all, 224 leaves were built up, of which 24 incorporated wicket doors. The leaves consisted of two main hollow extrusions with H-shaped cross members and diagonal bracings. The extrusions were designed to take a 1-in. diameter circular rubber draught-excluder which was bonded to them with "Bostik D." Recesses were incorporated in the extrusions into which fitted the edges of the 16-s.w.g. Mansard-type sheeting. The leaves, about 46 ft. high by 6 ft. wide, were sheeted both sides and were insulated with Fibreglass resin-bonded slabs.

ASSEMBLY JIGS FOR ALIGNING HINGES

The sheeting on one side was secured with $\frac{1}{4}$-in. diameter solid rivets; the other side, being inaccessible for backing-up the rivets, was secured by pop-riveting. The framework of the leaf was first jig-assembled to ensure squareness, jig-drilled in special jigs for hinge positions, sheeted on one side and riveted.

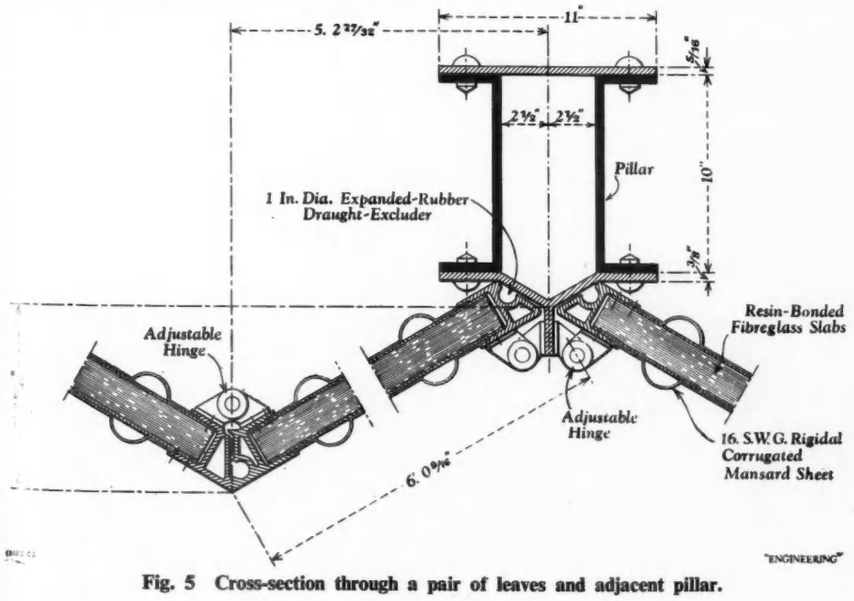

Fig. 5 Cross-section through a pair of leaves and adjacent pillar.

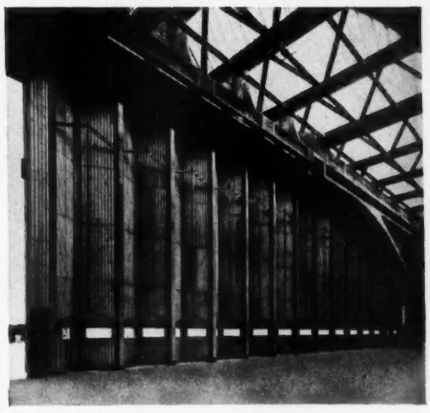

Fig. 4 Templex doors seen from within the hangar, showing the parallel-motion linkage and traction links.

The hinges were then attached and the Fibreglass insulation was inserted before final sheeting, inspection and storage ready for dispatch. The layout was for a production run and commenced from marking and cutting at one end of the shop to the completed leaf, ready for dispatch, at the other end. In order to ensure the hinges being accurately located on the pillars and leaves, a series of brick and concrete piers were set up into which were set fixed bushed drilling jigs. The jigs themselves were aligned by instrument and checked at intervals for movement. By using a joint set-up for pillars and leaves, a very high degree of accuracy was maintained throughout. A feature of the wicket doors was the swaging down of the Mansard sheeting to ensure flat surfaces for fitting the locks, handles, etc.

Eight pylon mullions and closure leaves, consisting in principle of pillars and leaves fabricated together as complete units, were constructed in the manner already described.

In the chamber containing the power unit is removable from the structure as a whole, and access to the driving units is through folding doors on the inside of the mullions.

In all, 232 window frames, of special extrusions, were assembled and the corners were Argon-Arc welded in jigs to ensure dimensional accuracy. The frames were assembled with galvanised countersunk setscrews into the apertures in the leaves. The glazing was of polished wired Georgian glass.

* * *

DEVELOPMENTS IN WELDING

German Exhibition and Conference

An exhibition of welding and cutting methods and appliances is being arranged to take place in the Grugapark at Essen from Saturday, June 12, to Monday, June 21, 1954, and will be on a larger scale than the previous exhibition in 1952.

There will be many practical demonstrations of new plant and testing procedures, and a feature of the exhibition will be the display of equipment by users of welding appliances.

During the course of the exhibition, there will be an international conference on "Welding Technology" at Essen, which will be held from Monday, June 14, to Wednesday, June 16.

Both events are being organised by the German Welding Engineering Association, the annual general meeting of which is being held, simultaneously with the conference, from June 13 to 16. The Corporation of Essen, represented by the Gemeinnützige Ausstellungsgesellschaft m.b.H., are assisting in the organisation of the exhibition. Further information may be obtained from the Association, Harkortstrasse 27, Düsseldorf, Germany.

210-MW NECHELLS "B" POWER STATION

MIXED COAL AND COKE FIRING RESULTS IN ECONOMY

The Nechells "B" power station in the Midlands Division of the British Electricity Authority, which was formally opened by the Lord Mayor of Birmingham (Alderman G. H. W. Griffith) on Tuesday, May 4, is worthy of attention for several reasons. The site, although close to the load centre, is restricted in area so that certain limitations were imposed upon the layout. During the construction of the station, it was necessary to maintain the output from the existing "A," or Prince's station, which it will eventually supersede. Moreover, as large quantities of coke dust are available from the adjacent works of the West Midlands Gas Board it was decided to use a mixture of this waste product with coal, instead of pulverised fuel. As a result it has been possible considerably to reduce the cost of generation.

SITE CONDITIONS

The site for the Nechells "A" station was acquired by the Birmingham Corporation in 1912 and constructional work had been begun when war broke out in 1914. Work was not resumed until 1918, but in the meantime the demand for power led to the construction of a temporary station on adjacent land. This station, which had an installed capacity of 22 MW, was not closed down until 1936. The Nechells "A" station was officially opened in 1923 and was completed in 1929, when it had an installed capacity of 140 MW. This, however, was not sufficient to meet the power requirements of the area, and two stations, with a total installed capacity of 570 MW, were subsequently built at Hams Hall, nearly nine miles north-east of the city centre. Plans were also made to demolish the Nechells "A" station, which was becoming obsolete, but they were not carried out owing to the outbreak of war in 1939.

Reconstruction at Nechells began in 1946, when, owing to the nature of the ground, nearly 7,000 reinforced-concrete piles, each 14 in. square and varying in length up to 25 ft., were driven by Sir Robert McAlpine and Sons (Midlands), Limited, Suffolk Street, Birmingham, to form the foundations of the building, boilers, cooling towers and turbo-alternators. The main building, which is illustrated in Fig. 1, is of brick-panelled steel-frame construction and is a little over 500 ft. long, nearly 400 ft. wide and 105 ft. high. Particular attention in its design was given to external appearance, which is exemplified in the two 350-ft. chimneys, the plinths of which are vertical to conform with the facade of the adjoining portion of the main building. Above this perpendicular portion is the base of the columnar section. This is constructed so as to be in alignment with the row of small windows at the top of the main building frontage. The bases of the chimneys are therefore unobtrusive and harmonise with the elevation of the building. The main contractors for the building superstructure were C. Bryant and Sons, Limited, Whitmore-road, Birmingham, 10, the structural steelwork being carried out by E. C. and J. Keay, Limited, Henley-in-Arden, near Birmingham.

The completion of the station was delayed in the early stages by shortage of materials, especially steel. The first set was, however, commenced in June, 1951, and the second six months later. Two other sets are being completed and ten out of the twelve boilers are now operational.

The coal-handling plant, which was installed by Mitchell Engineering, Limited, Peterborough, comprises two sets of duplicate wagon tipplers, gravity-bucket conveyors and inclined-belt conveyors, one for each line of boilers, with shuttle-belt conveyors over the bunkers. The plant is designed to handle standard 8-ton and 20-ton railway wagons, which are drawn in by the Authority's locomotives, and has a capacity of 120 tons per hour. The coal and coke are mixed in hoppers situated at the top of each bucket conveyor.

STEAM-RAISING PLANT

Each of the twelve boilers has an output of 230,000 lb. of steam per hour at a pressure of 675 lb. per sq. in. and a temperature of 850 deg. F. The temperature of the feed water at the economiser inlet is 340 deg. F. Each unit, for which the contractors were International Combustion, Limited, 19 Woburn Place, London, W.C.1, comprises a radiant boiler, superheater, economiser, air heater and stoker, as well as draught and grit-collecting plant. The boiler has four drums, including a steam receiver. The Lopulco fire-tube combustion chamber has a short refractory front arch and a completely cooled rear arch, the volume being 9,800 cubic feet with a rating of 2,800 B.Th.U. per cubic foot per hour. The stoker is of the twin "L" type and is 32 ft. wide by 22 ft. long, the rating being 46·2 lb. of fuel per square foot per hour. Superheating is effected by horizontal tube drainable elements, manufactured by the Superheater Company, Limited, Haymarket, London, S.W.1. These superheaters are coupled to headers, the primary inlet elements being connected through the steam receiver to the steam drum. The temperature of the steam is controlled by a gas by-pass damper. The Senior economiser has gas and water in contra-flow and is of the steaming type, three-banks high. There are two induced, two forced and two secondary fans for each boiler. These were manufactured by Davidson and Company, Limited, Belfast, and are driven by variable-speed alternating-current motors supplied by Laurence Scott and Electromotors, Limited, Norwich.

As already mentioned, the boilers were designed to burn a mixture of coal and coke dust in the ratio of 4 to 1. This fuel has a gross calorific value of 9,758 B.Th.U. per lb. with 12·2 per cent. moisture, 17·3 per cent. ash and a volatile content of 22·3 per cent. The guaranteed overall efficiency was 83·5 per cent., but this was improved upon by a small margin during the official acceptance tests.

ASH DISPOSAL

The ash is removed by a continuous closed-cycle water system to a settling sump on the west side of the building, there being three lines of sluices to each line of boilers, which handle rough ash, riddlings and grit, respectively. The fine and coarse ash is segregated in the sump and grabbed thence by duplicate travelling telphers, which deposit it into hoppers. It is taken from these either by road vehicles or railway wagons. The main contractors for this plant were International Combustion, Limited. The telphers were supplied by Strachan and Henshaw, Limited, Bristol, and the four vertical-spindle pumps for circulating the water, which are installed in a separate pump house, by Gwynnes Pumps, Limited, Lincoln.

GENERATING PLANT

The turbine room is illustrated in Fig. 2. Its equipment consists of four three-cylinder 52·5-MW turbines, which were constructed by C. A. Parsons and Company, Limited, Newcastle-upon-Tyne. Each is coupled to a main 50-kW alternator and a 2·5-MW auxiliary alternator, the speed being 3,000 r.p.m. Two governor valves and a separate emergency stop valve are housed in a steam chest alongside each set and are operated by oil supplied from a pump at the end of the high-pressure turbine shaft.

Steam is expanded in the high-pressure cylinder from 650 lb. to about 135 lb. per square inch and is then led through a pipe below the operating floor level to the intermediate-pressure cylinder. Here it is expanded to 13 lb. per square inch and

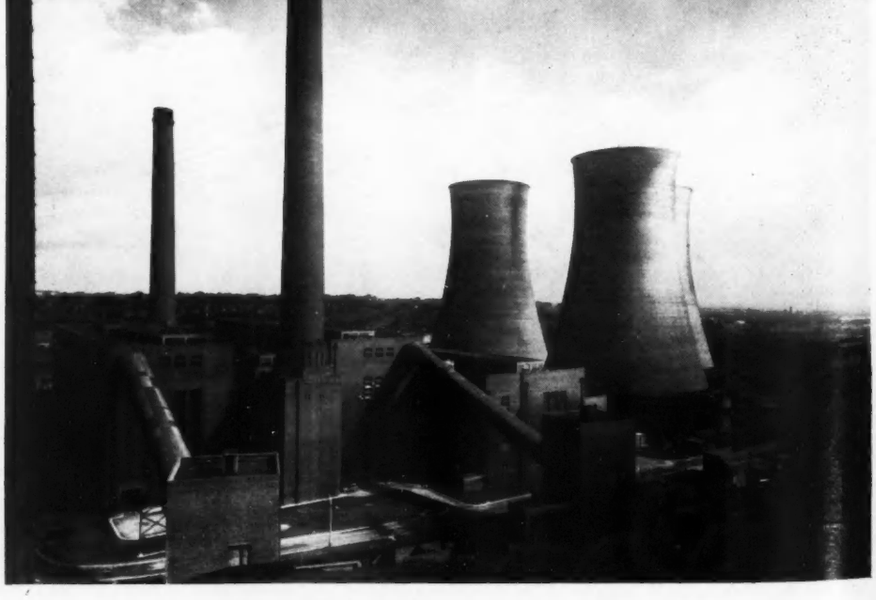

Fig. 1 Exterior of Nechells "B" power station.

passes through two overhead pipes to the low-pressure cylinder where it is further expanded to the exhaust vacuum which is 28·5 in. at economical load. Steam is tapped off at pressures of 180 lb., 64 lb., 16 lb. and 6·5 lb. per square inch for feed-heating purposes.

Each turbine exhausts into a double-inlet condenser with a cooling surface of 60,000 sq. ft., from which air is extracted by three 50 per cent. duty two-stage steam-jet operated air ejectors. The associated pumping plant consists of two 80 brake horse-power extraction pumps, which were manufactured by Drysdale and Company, Limited, Glasgow, and three 580-h.p. circulating-water pumps, which were constructed by Mather and Platt, Limited, Manchester, 10. These pumps are all of the vertical-spindle type and are driven by 3·3-kV slip-ring induction motors. The extraction pumps discharge through two Parsons low-pressure heaters to the feed pumps, which were also manufactured by Mather and Platt, Limited, and are capable of supplying 600,000 lb. of water per hour at a pressure of 880 lb. per square inch to the boilers. One of these feed pumps is electrically driven, the other being driven by steam.

The make-up water is obtained from two bled-steam evaporators for each turbine, which are designed to give 2 per cent. make-up at all loads when operating double-effect and 4 per cent. when evaporating single-effect. An auxiliary supply of 25,000 lb. of distilled water per hour is obtainable from a separate live-steam plant. The water for these evaporators, which were manufactured by Aiton and Company, Limited, Derby, is drawn from reserve tanks into which town's water is fed after treatment in a base-exchange softening plant supplied by John Thompson-Kennicott, Ltd., Wolverhampton.

The circulating water is cooled in three 296-ft. reinforced-concrete cooling towers, the main contractors for the construction of which were Fred. Mitchell and Son, Limited, Bishopsgate, London, E.C.2. Each tower has a capacity of 3,200,000 gallons of water per hour with a cooling range from 92 deg. to 76 deg. F. when the wet-bulb temperature is 56·3 deg. F. and the humidity 80 per cent. The pond make-up water is taken from the River Tame by four pumps, each with a nominal capacity of 3,000 gallons per minute.

ALTERNATORS

The main alternators are designed to supply three-phase current at 11 kV and a power factor of 0·8; and the auxiliary alternators generate three-phase current at 3·3 kV and the same power factor. The exciters for each machine are installed alongside the foundation block in the basement and are electrically driven at a nominal speed of 1,000 r.p.m. An auxiliary exciter is mounted on the same shaft as the main exciter.

Cooling of the main alternators is effected by two separately driven fans which operate on a closed circuit. The air coolers are installed in the foundation block and are supplied with water from the condenser circulating system. The auxiliary alternator is cooled by a fan on each end of the rotor and a separate cooler.

MAIN AND DISTRIBUTION SWITCHGEAR

Owing to the need for keeping the "A" station in operation during the construction of the "B" station and subsequently to retain five of the sets in the former in service, the electrical control system is complex; it was fully described on page 502 *ante*. It may be recalled, however, that the switchgear controlling the first two machines consists of two groups of the General Electric cellular pattern, which is installed in the "A" station and has been operated to 1,000 MVA. The other two machines are controlled by General Electric metal-clad equipment of the same rating, which is installed in the "B" station, the two being connected by a cable tunnel. Extensive use has been made of reactors to limit the fault power on the main bus-bars and on the distribution switchgear.

This distribution switchgear is divided into five groups in the "A" and two in the "B" station, all of which is now rated at 250 MVA. That in the "A" station comprises one group of Reyrolle gear, two groups of cellular and two groups of metal-clad gear, both of which were manufactured by the General Electric Company. The new metal-clad switchgear in the "B" station was also supplied by the General Electric Company. Each of these seven groups is fed from the main bus-bars through a 30-MVA booster reactor with automatic voltage control.

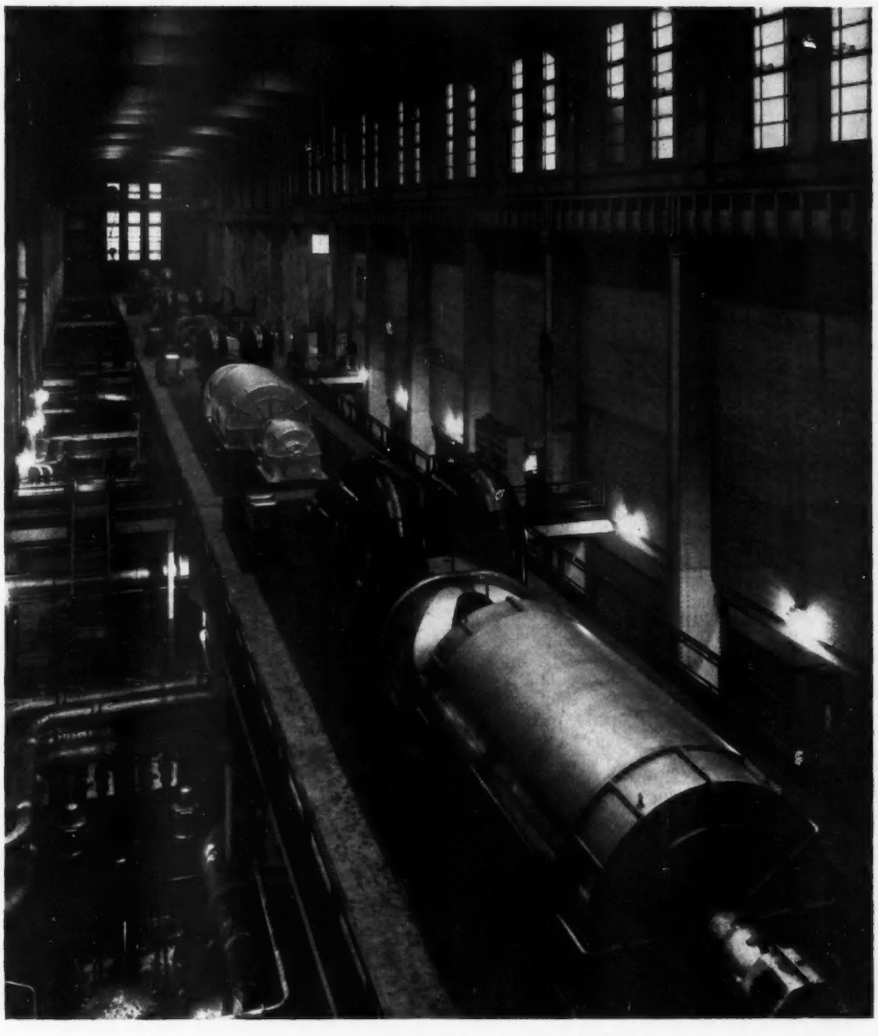

Fig. 2 Turbine room showing the main sets and the auxiliary annexe.

AUXILIARY SUPPLY

The station auxiliary supply is obtained from four 2·5-MVA auxiliary transformers, which were manufactured by the Yorkshire Electric Transformer Company, Limited, Thornhill, Dewsbury, and three 6-MVA, 11/3·3 kV station transformers, constructed by Ferranti, Limited, Hollinwood. The auxiliary alternators can be paralleled with the works transformers as the main machine is being brought up to load or when the load is being reduced.

The larger motors are operated at 3·3 kV and the smaller, as well as the lighting and general services, at 415/240 volts. The 3·3 kV switchgear was manufactured by the English Electric Company, Limited, Kingsway, London, W.C.2, and is of the air-break type with a rating of 150 MVA. The 415-volt switchgear was manufactured by the same firm and is rated at 25 MVA.

CONTROL ROOM

The 11-kV switchgear is operated from a mimic-diagram remote-controlled switchboard in a separate control room. This board, which is 102 ft. long, is arranged in a semi-circle round a desk, with the 3·3 kV control board for the works supply on the opposite side of the room. The centre section of the main board controls the four groups of 11-kV switchgear and on the other side of it are the controls for the adjacent 132-kV grid substation. This sub-station is connected with the power station through three 45-MVA transformers. All the equipment in the control room was installed by the General Electric Company, Limited.

The scheme we have described was initiated by Mr. F. W. Lawton, who was the chief engineer and manager of the Birmingham Corporation Electricity Department. It was continued under his supervision as Divisional Controller of the Midlands Division of the British Electricity Authority until his retirement. The present Divisional Controller is Mr. R. L. Batley.

THE P. & O. LINER "ARCADIA"

MACHINERY, BOILERS AND EQUIPMENT

Concluded from page 475

PROPELLING MACHINERY

The main propelling machinery of the Arcadia, which was constructed at Clydebank, consists of twin-screw geared turbines, taking steam from water-tube boilers. The normal shaft horse-power, as previously stated, is 34,000, the corresponding revolutions of the propellers being 130 per minute; but the installation is capable of delivering 42,500 s.h.p. at 140 r.p.m. The astern turbines develop about 65 per cent. of the normal ahead power of 34,000 s.h.p.

The turbines are of the impulse-reaction type and each set comprises a high-pressure turbine, an intermediate-pressure and a low-pressure, working in series. Steam is supplied to the high-pressure turbine at a pressure of 500 lb. per sq. in. and a temperature of 800 deg. F. The condensers are designed to give a vacuum of 28 in. with a sea temperature of 86 deg. F., and 28·85 in. with a sea temperature of 65 deg. F.

The high-pressure turbines have two rows of impulse blading, on a wheel which is forged solid with the rotor; and five stages of reaction blading, totalling 29 rows. The reaction blades are end-tightened and are assembled in segments, with mild-steel packing and side locking-strips of Lowmoor iron. The intermediate-pressure turbines have reaction blading only, in seven stages comprising 35 rows, on a rotor of the hollow-forged drum type. The low-pressure turbines also have this form of rotor and are of the double-flow type, with the steam inlet at the centre. Each half of the turbine has 11 single rows of reaction blading, segmentally fitted.

Each set of machinery contains two astern turbines, working in series, both turbines being of the impulse type. The high-pressure astern rotor, which has three impulse rows, is shrunk on to the forward end of the intermediate-pressure ahead rotor and is contained in the same casing. The low-pressure astern turbine, which also has a three-row wheel, is incorporated in the low-pressure ahead casing and is attached to the forward end of that rotor.

Dummy cylinders are provided in the high-pressure and intermediate-pressure turbines to balance the steam thrust, any unbalanced thrust being taken on Michell thrust bearings. The Aspinall governors, fitted to all the turbines, cut off the steam if the lubricating-oil pressure falls below the predetermined figure or in the case of overspeeding. The axial clearances of the high-pressure and intermediate-pressure turbines can be adjusted while running. The shaft glands on all turbines have double pockets, the inner pockets being connected to receivers and the outer pockets to the gland condensers.

The impulse blades throughout are made of Hecla A.T.V. steel and are separately fitted into the grooves in the wheels and cylinders. The reaction blading is of Monel metal or of stainless iron. As stated above, it was assembled in segments, the roots being secured together by brazing. All the rotors were dynamically balanced after blading. The nozzle plates of the high-pressure ahead turbine are of fabricated construction; those of the astern turbines are steel castings. In each case, the nozzle vanes are of Hecla A.T.V. steel.

The casings of the high-pressure ahead turbines are molybdenum-steel castings, those for the intermediate-pressure ahead turbines and the astern turbines are of cast steel, and the low-pressure casings of cast iron.

MAIN GEARING

The main gearing is of the double-helical type, the drive from the high-pressure turbines being through double-reduction gears and for the other ahead turbines, single reduction, with claw couplings. The gearcases are of fabricated construction. The high-pressure turbine primary pinions, of nickel steel, have all-addendum teeth of $\frac{7}{12}$ in. pitch and a pitch-circle diameter of 13·71 in. The face width is 31 in., and there is a gap of 3 in. between the helices. The forged-steel primary gearwheels have a pitch-circle diameter of 34·49 in. The secondary gears have teeth with a pitch of $\frac{7}{16}$ in., the high-pressure pinions having a pitch-circle diameter of 17·03 in. and the intermediate and low pressure, 12·62 in. All the secondary pinions have central bearings. The main gearwheels, constructed with forged-steel rims shrunk on to cast-iron centres, have a pitch-circle diameter of 174·09 in. and a face width of 49 in. All the pinions were dynamically balanced before assembly, and the main gearwheel was statically balanced. At full power, the high-pressure turbines run at 3,600 r.p.m. and the intermediate-pressure and low-pressure turbines at 1,931 r.p.m. The turning gear, which operates on the pinions of the low-pressure turbines, is electrically driven and can turn the set at the speed of one revolution of the main shafting in 10 minutes.

For the lubrication of the turbine bearings and the gearing there are three electrically-driven "Vertoil" pumps, supplied by Drysdale and Company, Limited. Two of the pumps suffice to carry the normal load, the third being a standby unit. Each is capable of delivering 25,000 gallons of oil an hour against a head of 55 lb. per square inch. The suctions are fitted with Chapman magnetic filters, supplied by Smith, Lemon and Stewart, Limited. The pumps deliver through Autoklean "Flush Flow" strainers and Serck oil coolers to the gravity tanks, which have a capacity sufficient to ensure a supply of oil for about 5 minutes, in the event of failure of the pumps. Two "Titan" centrifugal oil purifiers, each able to deal with 350 gallons an hour, have been supplied by Ferguson and Timpson, Limited.

The propeller shafting is of solid-forged steel, and is supported in Michell self-lubricating bearings. The four-bladed solid propellers, of manganese bronze, are 19 ft. in diameter; they were supplied by Bull's Metal and Marine Company, Limited. Their thrust is transmitted through Michell single-collar thrust blocks, and the horse-power is measured by a Siemens-Ford electrical torsionmeter on each shaft.

CONDENSERS AND CLOSED-FEED SYSTEM

The main condensers are of Weir's two-flow regenerative type and are underslung, one below each low-pressure turbine. Each has a cooling surface of 17,500 sq. ft. and will pass 134,000 lb. of steam an hour; the tubes, of cupro-nickel, are $\frac{3}{4}$ in. external diameter and 18 l.s.g. thick. The condenser body is of mild steel. Crane's flexible metallic packing is used to pack the tubes in the tubeplates. As the condensers form part of the Weir closed-feed system, the condensate wells in the body are made large enough to allow for small variations in the flow of feed water. A Weir automatic closed-feed controller is fitted, consisting of a 6-in. supplementary feed valve and a 4-in. overflow valve, operated by a single float, to allow water to be drawn into the condenser from the main feed-tank, should the water level in the condenser fall as the result of a sudden demand by the feed pumps. If the water level in the condenser rises beyond a certain point, the surplus is discharged to the feed tank. Kenotometer gauges, supplied by Brady and Martin, Limited, are fitted to measure the vacuum.

For each condenser there are two vertical-spindle centrifugal extraction pumps, one working and the other a standby unit; they are electrically driven, and each has a capacity of 258,000 lb. an hour against a head of 30 lb. per square inch. The three main feed pumps (two working and one standby) are turbine-driven. Each pump can deliver 350,000 lb. an hour at a pressure of 725 lb. per square inch. There is also an auxiliary turbo feed-pump with a capacity of 50,000 lb. an hour, and an electrically-driven feed pump for harbour use, with a capacity of 52,000 lb. an hour. All the feed pumps and extraction pumps, and also the oil-fuel transfer pumps, have been supplied by G. and J. Weir, Limited.

The operation of the closed-feed system is as follows. The condensate first passes through the steam air-ejector, which maintains the vacuum in the condenser. This ejector is of the three-stage type and can deal with 72 lb. of air and 120 lb. of vapour an hour, using for its operation 1,100 lb. of steam an hour at a pressure of 250 lb. per sq. in. and a temperature of 750 deg. F. From the ejectors the feed from both the port and starboard condensers passes through the glands-condenser drain cooler, which has a tube surface of 800 square feet, and so to the suctions of the feed pumps. A Weir de-aerator is provided for use in harbour and under low-power conditions; it can handle 66,000 lb. of feed water an hour under harbour conditions and 125,000 lb. an hour at sea.

From the feed pumps the feed water is discharged to the first low-pressure heater, which has a tube surface of 950 sq. ft. and is supplied with vapour from the salt-water evaporators. It then enters the second low-pressure heater, which has an area of 1,050 sq. ft. and takes its vapour from the fresh-water evaporator, the coil drains, and the drain from the high-pressure heater. Finally, the feed water passes through the high-pressure heater, which has a tube surface of 770 sq. ft. and is supplied with bled steam from the main turbines. It is delivered to the boilers

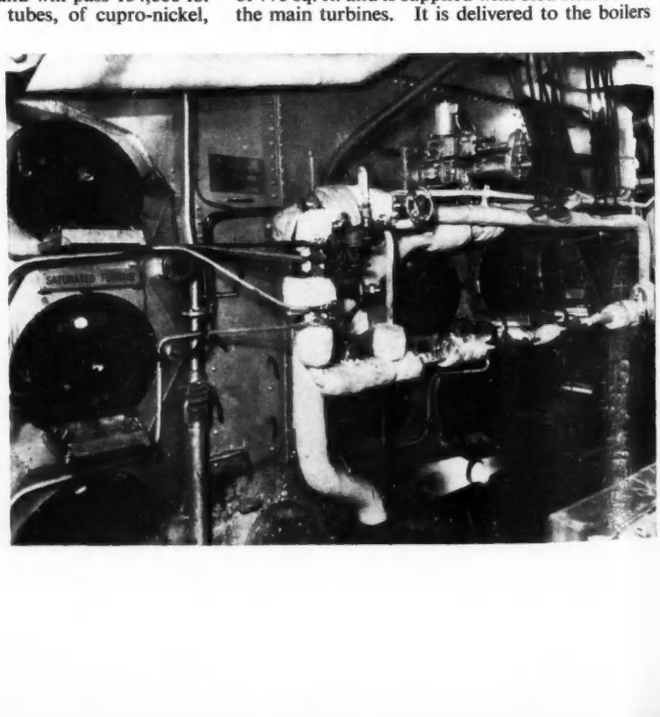

Fig. 4 Boiler front, showing saturated and superheat furnaces.

at a temperature of 280 deg. F., the rate of supply being controlled by the Weir " Robot " feed regulators.

OTHER AUXILIARY MACHINERY

The vertical-spindle main and auxiliary circulating pumps, the bath-water pumps and the sanitary pumps were supplied by W. H. Allen, Sons and Company, Limited; and the general-service, bilge, fresh-water, drinking-water and emergency fire pumps by Drysdale and Company, Limited. Each circulating pump can deliver 12,000 gallons of sea water per minute against a total head of 26 ft., or 16,000 gallons a minute against a head of 20 ft. The motors, also supplied by Messrs. Allen, are rated at 155 brake horse-power and have a speed range from 375 to 560 r.p.m. The pump which supplies water to the baths is a vertical-spindle unit with a capacity of 224 gallons per minute against a head which may vary from 25 to 90 ft., and is driven by an Allen motor of 9½ h.p., running at 1,150 to 1,600 r.p.m. For the sanitary services there are two vertical-spindle pumps, with a capacity of 220 tons an hour (823 gallons a minute) against a maximum head of 120 ft. The motors, also by Messrs. Allen, are rated at 47 h.p. and have a speed range of 1,300 to 1,700 r.p.m.

Messrs. Drysdale and Company supplied the " Pneupress " pressure-control system, which includes a Mather and Platt air compressor, for the supply of water to the officers' cabins and other accommodation in the superstructure. The lime-mixing plant was supplied by the Candy Filter Company, Limited. There is also an air compressor, supplied by Broom and Wade, Limited. Crockett " Simplex " salinometers are fitted in the closed-feed system, the evaporator system, and the turbo-generator system. The engine-room is ventilated by eight torpedo fans supplied by Thermotank, Limited.

The evaporating and distilling plant, which was supplied by Messrs. G. and J. Weir, Limited, is of the type introduced by Mr. S. A. Smith, the superintendent engineer of the P. & O. Company, for the purpose of enabling the vessel to depend almost entirely on sea-water distillation for the maintenance of the normal consumption of fresh water; it has a capacity of 550 tons a day, and uses the first low-pressure feed-heater as a distiller for the vapour from the sea-water evaporator, thus recovering in the feed water most of the heat expended in evaporation. Some of the condensate from the first low-pressure heater is pumped to the fresh-water evaporator as make-up feed and the rest passes, through a cooler, to a storage tank for domestic use. The vapour from the fresh-water evaporator is condensed in the second low-pressure heater and led to the drain cooler.

The complete evaporating and distilling plant comprises six salt-water evaporators, each having a surface of 1,050 sq. ft.; one distilled-water cooler and primary feed-heater for the salt-water evaporators, with a surface of 900 sq. ft.; a secondary feed-heater for the salt-water evaporators, with a surface of 1,000 sq. ft.; a fresh-water evaporator, having a surface of 300 sq. ft. and a capacity of 75 tons a day; and two distilling condensers, each capable of dealing with 150 tons of vapour a day. The pumping equipment consists of two feed pumps, two brine pumps, and two fresh-water pumps.

The refrigeration machinery, by J. and E. Hall, Limited, consists of six CO_2 compressors, each driven by an Allen motor of 140 h.p. with a speed range of 1,200 to 850 r.p.m. Allen motors, two of 80 h.p., one of 15 h.p., and one of 5 h.p., are also used to operate the Denny-Brown stabilisers, which are similar to those fitted in the P. and O. liner Chusan.

BOILERS

The steam-generating plant of the Arcadia consists of three Foster-Wheeler water-tube boilers of the controlled-superheat type, each with two furnaces; they were constructed under licence by John Brown and Company at Clydebank. Steam is supplied at a pressure of 530 lb. per square inch at the superheater outlet, and normally at a temperature of 850 deg. F., which, however, can be reduced, if required, down to a temperature of 600 deg. F. Each boiler has a generating surface of 20,355 sq. ft. and a superheater surface of 2,525 sq. ft., and is designed for a normal evaporation of 105,000 lb. an hour. The maximum continuous rating is 165,000 lb. an hour. There are 12 oil-fuel burners, five in the outboard furnace and seven in the inboard furnace.

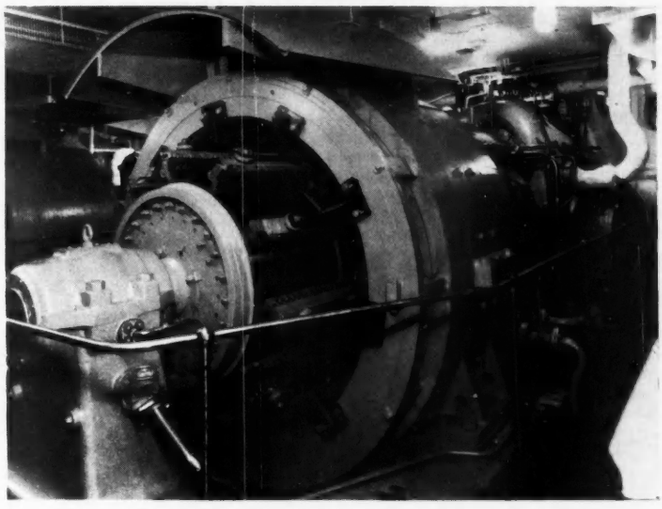

Fig. 5 B.T.H. generator with enclosed air-cooled field windings. The air passes in a closed circuit through a Serck air cooler, with water circulation.

The floor, walls and roof of the outboard furnace are formed of a single row of water tubes, 2 in. outside diameter; and the floor and walls of the inboard furnace of similar tubes, also in a single row. The two furnaces are separated by an intermediate bank of tubes, comprising seven rows of tubes of 1¼ in. outside diameter and four rows of 2 in. outside diameter. The superheater consists of five loops of 1¼-in. tubes, expanded into the header and protected by three rows of 2-in. tubes; it is situated between these three rows and the 21 rows of 1¼-in. tubes which form the main bank, which are on the far side of the superheater from the inboard furnace. This position ensures that the variation in steam temperature is kept to the minimum.

Each boiler is equipped with a Green's economiser, with cast-iron gilled tubes, and a Howden-Ljungstrom air preheater; a double-inlet forced-draught fan, capable of delivering 60,000 cub. ft. of air per minute against a pressure of 10 in. w.g.; and an induced-draught fan, with a capacity of 92,000 cub. ft. of flue gases per minute against a pressure of 15·5 in. w.g. The fans were supplied by James Howden and Sons, Limited; they are driven by Allen pipe-ventilated motors, with combined shunt and series speed regulation. The motors of the forced-draught fans are of 151 h.p. and have a speed regulation of about 4½ : 1 between maximum and minimum speeds. The motors of the induced-draught fans are of 400 h.p., with a speed range from 900 to 125 r.p.m. The controllers for both sets of fans are of the automatic-contactor type, with remote-control units in the stokehold. If required, the fans can be stopped from the contactor unit and restarted to any speed preset by the remote unit.

The oil-burning installation consists of three Wallsend-Howden " Simplex " pumping and heating sets, two working and one in reserve. Each pump and heater can deal with 13,500 lb. of fuel an hour at a delivery pressure of 300 lb. per square inch. The pumps were supplied by G. and J. Weir, Limited.

Each boiler steam drum is fitted with low-level alarm and oil-fuel safety shut-off gear, made by Alexander Stephen and Sons, Limited. Steam soot-blowers, electrically operated, have been supplied by Clyde Blowers, Limited, for the three boilers and their air heaters. Two " Mono " CO_2 recorders, which can be switched on to any boiler, have been supplied by James Gordon and Company, Limited. The boiler mountings and safety valves were made by Cockburns, Limited, and the main steam pipes by the Chesterfield Tube Company. To ventilate the boiler room there are six Thermotank torpedo fans.

The uptakes from the three boilers are led to a single funnel, of somewhat unusual design. It tapers from the deck upward and is surmounted by a rounded top, covering the annulus between the funnel and the casing, and giving an upward deflection to the gases which, it is calculated, will carry all smuts clear of the sports deck when the vessel is under way. The design has been evolved jointly by John Brown and Company, the P & O. Company, and Thermotank, Limited, in whose wind tunnel smoke tests were carried out to determine the final form. The weight of the funnel with its casing, the uptakes and the internal fittings is about 85 tons.

ELECTRICAL PLANT

The electrical requirements of the ship, both for driving the auxiliaries and for domestic purposes, are provided by three turbine-driven direct-current sets supplied by the British Thomson-Houston Company, Limited. Each set has a normal output of 1,200 kW at 225 volts and an overload capacity, for two hours, of 1,500 kW. Each has its own condenser, closed-feed control valve, air ejector and extraction pump. The turbines are designed to take steam at 500 lb. per square inch and the full superheat temperature of 850 deg. F., with a vacuum of 28½ in. and a sea temperature of 73 deg. F. They run at 5,500 r.p.m. and drive the compound-wound generators at 600 r.p.m. through single-reduction double-helical gearing. The field windings of the generators are completely enclosed and air-cooled. The air passes in a closed circuit through a Serck air cooler, with water circulation.

The two emergency generating sets have been supplied by Ruston and Hornsby, Limited. Each consists of a five-cylinder oil engine directly coupled to a direct-current generator, made by W. H. Allen, Sons and Company, with an output of 100 kW at 225 volts when running at 600 r.p.m. The generator room, on the upper deck forward, is ventilated by two Thermotank torpedo fans.

Reference has been made to a number of motors supplied by W. H. Allen, Sons and Company to drive auxiliary machinery. Others supplied by the same firm include those of the three forced-lubrication pumps, three bilge pumps, one fire and bilge pump, one general-service and ballast pump, and the four main extraction pumps.

A considerable amount of the electrical equipment in the ship has been supplied by the General Electric Company, Limited, whose contracts included the fluorescent and tungsten lighting installations throughout the principal

passenger spaces, the telephone exchange and instruments, the stewards' luminous call systems, the fire alarm system, and plural starters for the motors driving some of the auxiliary machinery.

The fluorescent lighting operates on alternating current at 230 volts and 50 cycles. The transformers for operating the Osram cold-cathode tubes used in the public rooms are concealed in the spaces between the false ceilings and the deckhead, and are designed with the terminals at the sides of the casings so as to be accessible without removing the main covers. For cornice lighting, hot-cathode tubes are used in two sizes, namely, 20-watt tubes 2 ft. long, and 40-watt tubes 4 ft. long. A motor-operated dimmer is provided to control the cold-cathode lighting on the first-class dancing space.

The telephone exchange equipment comprises both automatic and manual units, with the batteries, etc., for operating them. There are four automatic units for the ship's purposes, giving 117 extension lines and three junction lines to the manual switchboard. The two-position manual switchboard has 500 extension lines for passengers, and six shore lines. The power supply, at 24 volts, is on the duplicate-battery system, one battery being on charge while the other is in use. A wall-mounted charging regulator is provided, connected to the ship's 220-volt direct-current supply, and maintains the battery in use at between 22 and 26 volts.

The stewards' luminous call system operates a 62-way master indicator and also a 21-way indicator in the tourist-class accommodation, with lamps over the cabin doors and in the alleyways to identify the cabin originating a call. When a call is answered, the operation of a reset unit extinguishes the local and central indicator lamps. There are 802 call pushes, 424 reset units, and 485 identifying lamps.

The fire-alarm system provides 21 alarm pushes, with a 21-way indicator on the bridge. There is direct telephone communication from the bridge indicator to each of the alarm points, the positions of which are marked by permanently-illuminated lamps, behind a red window at the top of the case containing the alarm push.

Twenty-three electric motors, ranging from 8 h.p. to 155 h.p., are controlled by plural starters of the General Electric Company's type; 16 of them are on the " essential " bus-bars. Two common starters are provided, one being a standby unit, and are mounted on the main switchboard. Each motor has its own push-button control, either mounted on the motor or near to it. At the switchboard is a motor-driven drum controller and starting resistance, the early resistance steps being cut out by the drum segments and the later ones by the operation of contactors. One field winding of the driving motor is connected across the resistance, so that the speed of rotation of the controller is reduced automatically when starting a large machine taking a heavy current.

NAVIGATING, RADIO AND RADAR EQUIPMENT

The Arcadia has been provided with three dry-card compasses – the standard compass, steering compass and an additional compass aft – by Kelvin and Hughes, Limited, who have also supplied the chart-room fittings (clocks, barograph, star globe, etc.), and a Kelvin-Hughes " Autominor " sounding machine, with its 1½-h.p. electric motor and 300 fathoms of steel wire.

The Sperry Gyroscope Company, Limited, have installed a Sperry Mk. XIV gyro-compass and a Sperry two-unit Gyropilot. The master compass operates two bearing repeaters, one on each wing of the bridge, the repeater in the observation lounge, a steering repeater with an enlarged scale, mounted on the bridge unit of the Gyropilot, and a course recorder. The Gyropilot provides both hand-electric and automatic steering. In the wheelhouse there is also a Sperry rudder-angle indicator, actuated by a transmitter which is moved by the rudder stock. This system operates on alternating current and is self-synchronous.

The Marconi International Marine Communication Company, Limited, were the contractors for the installation of radio equipment and electronic aids to navigation. The main radio transmitter is the Marconi " Worldspan " type, designed for world-wide communication and to carry a heavy traffic on the short and medium wavebands. It gives instantaneous " spot " tuning, by a system of click selectors, to any one of 37 preselected wavelengths; 30 of these, in the short-wave band, are crystal-controlled. Automatic keying facilities are provided for emergency use, and a " Reliance " medium-wave transmitter is also installed for emergency and auxiliary purposes.

Two radio receivers are fitted, a " Mercury " and an " Electra." These, in conjunction with the " Worldspan," cover reception on low, medium and high frequencies, with an overlap in the medium band which enables either receiver to be used on 500 kilocycles per second while the other is receiving on another frequency. A separate emergency watch receiver is also fitted; and two of the lifeboats are equipped with permanently-fixed transmitter-receivers.

For radio-telephony there is a bench-mounted version of the Marconi Company's " Oceanspan " transmitter, with an all-wave receiver, providing facilities for long-range speech on short and medium waves, and for telephone-link calls to short systems.

The radar equipment consists of a Marconi Marine " Radiolocator," type IV. There is also a long-range direction-finder, and a " Visagraph " echometer, which gives both a visual indication and a permanent record of the depth of water beneath the vessel.

The public-address system consists of 156 loudspeakers. There is a separate boat-order system, interlocked with the ship's system so that, when the boat-order system is brought into use, adjacent loudspeakers on the ship's system are automatically muted. The ship's sound-reproducing system is so arranged that four entirely separate programmes can be relayed simultaneously to different parts of the ship. A twin-motor wire recorder is included in the equipment, so that items which may be received at a time when it is inconvenient to use the loudspeakers can be stored until a more suitable time.

In addition to the ship's telephone system, described above, and the public-address system, special watertight telephones are fitted for navigational purposes, in the exposed positions on the bridge, etc. These have been supplied by Alfred Graham and Company, Limited, who have also provided the two loud hailers, mounted on the bridge. Two Tyfon steam whistles, made by Kockums Mekaniske Verkstads A/B, of Malmö, Sweden, are mounted on the funnel; they are housed within the funnel casing, only the end of the trumpet projecting. A 24-in. searchlight, with the divided reflector required by Suez Canal regulations, has been supplied by Clarke, Chapman and Company, Gateshead-on-Tyne.

Three bower anchors and a stream anchor are carried, all of the Byers type. The bower anchors weigh 8 tons 1 cwt. and the stream anchor 3 tons 6 cwt. The anchor cables have 3⅛-in. stud links and a total length of 330 fathoms. They are handled by a Clarke, Chapman combined anchor and warping windlass, driven by two totally-enclosed electric motors of 112-h.p. each, which can also drive the port and starboard warping capstans. Two smaller warping capstans are fitted aft, each driven by an electric motor of 64 h.p.

For cargo-handling there are seven 3-ton derricks and one 10-ton derrick, served by 18 electric winches supplied by Clarke, Chapman and Company. These are driven by 26-h.p. motors and can lift 3 tons at a rate of 100 ft. per minute.

STEERING GEAR

The steering gear, of the electro-hydraulic type, was supplied by Brown Brothers, Limited, Edinburgh, and is fitted with two independent motors, each of 70 h.p. and driving a V.S.G. variable-delivery pump. Either motor can move the rudder from hard-over to hard-over – a total angle of 70 deg. – in 30 seconds. If necessary, the two units can work together, in which case the time taken is approximately halved.

There are 18 lifeboats, of which six are motor-propelled; two of these can accommodate 136 persons each and the other four, 80 persons. Of the ten boats fitted with Fleming hand propulsion, six carry 145 persons and the remainder 99. The two rowing lifeboats carry 47 persons each. All of the boats were constructed by Mechans, Limited, Glasgow. They are carried in Welin-Maclachlan gravity davits.

FIRE-EXTINGUISHING EQUIPMENT

The arrangements for the detection and extinction of fire are in full accordance with the highest requirements of the Ministry of Transport. Mather and Platt, Limited, Manchester, have provided a very extensive installation of Grinnell automatic sprinklers and fire alarms, covering the whole of the passenger and crew accommodation. The vessel is divided into 34 zones for this purpose, each having its alarm indicator on the bridge. The system is kept charged with water from a tank of 1,000 gallons capacity, maintained under an air pressure of 120 lb. per square inch by a small compressor. The operation of any sprinkler, by reducing the pressure in the main, starts an electrically-driven centrifugal pump which keeps the tank fully charged. In the boiler room there is a Pyrene mechanical foam plant, discharging through 30 nozzles. The Pyrene Company have also supplied the automatic smoke-detecting equipment which protects the cargo holds.

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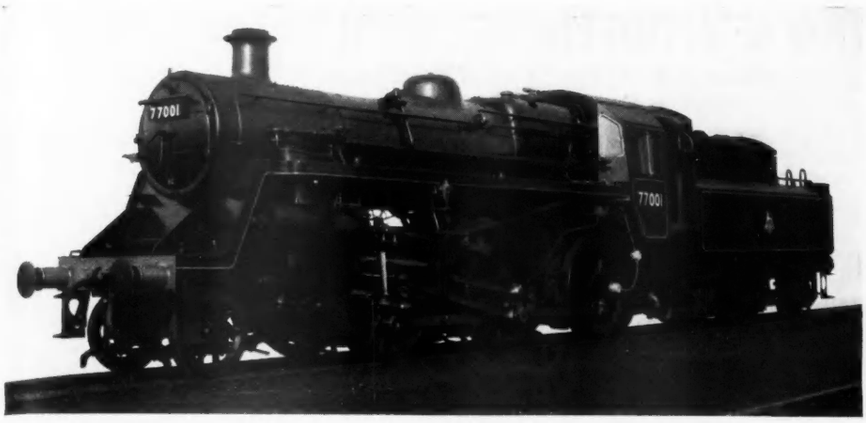
HARVESTING MACHINERY FOR SEAWEED

The activities of the Institute of Seaweed Research are mainly of a chemical nature, but if seaweed is to be used for the manufacture of animal foodstuffs, or as a soil conditioner, large quantities will be necessary for commercial exploitation.

Harvesting of seaweed might be described as an engineering operation. It appears from the annual report of the Institute for the year 1953, published from the headquarters at Inveresk, Midlothian, that the staff of the Engineering Division is larger than that of either the Botany or Chemistry Divisions.

The main work of the Engineering Division has been the development of continuous harvesting machinery for brown sub-littoral seaweed. A large grapnel towed by a motor vessel has been operated at sea for more than 100 hours, and it would appear that the most useful lesson learned is that " a much higher standard of mechanical reliability is necessary " before " this form of equipment can be seriously considered as the pattern for a commercial harvester." The grapnel or " belt " as it is termed in the report, must cut a wide track through the seaweed growth; its horizontal movements must be restricted and its vertical movements must follow the contours of a rough sea bed.

A suction method of harvesting seaweed has also been employed but an outstanding difficulty has been to ensure that the cut plants entered the suction inlet. The behaviour on the sea-bed could not be observed and it was impossible to experiment under controlled conditions. In order to obtain information about undersea performance a model experimental tank, fitted with Perspex observation windows, has been built. The tank is fitted with winch gear to tow model harvesting grabs. In addition, a photographer-diver has been engaged. It is hoped that he will be able to obtain photographs of the machine in action.



British Railways' new 2-6-0 tender engine is the eleventh in the series of 12 standard designs. The locomotive shown here is fitted with a speedometer, the drive being taken from the left rear wheel.

STANDARD 2-6-0 TENDER ENGINE FOR BRITISH RAILWAYS

The eleventh of the 12 standard types of steam locomotives being designed and built by British Railways is a Class 3 tender engine (tractive effort 21,490 lb.) with a 2-6-0 wheel arrangement. It is generally similar to the Class 3 tank engine which appeared two years ago,* the only significant difference, apart from coal and water carrying arrangements, being the use on the new tender engine of a reversing screw in which the screw itself is located forward near the cross-shaft instead of in the cab. This arrangement, which is shown in the illustrations on this page, has already been used on the standard tender engines of Classes 4, 5, 6 and 7. The 12th of the series of standard locomotives, details of which are expected to be published shortly, will be British Railways' largest 4-6-2 engine, designed for express passenger traffic only.

Twenty Class 3 locomotives are to be built at the Swindon Works of the Western Region. Ten are to be allocated to the North Eastern Region and ten to the Scottish Region. The engines are numbered 77000 to 77019 and were designed under the direction of Mr. R. A. Riddles, who at the time was the Railway Executive member for Mechanical and Electrical Engineering. The parent office for design was Swindon but certain details were undertaken at Brighton, Derby and Doncaster. Like the tank version, the tender type has almost universal availability over main and secondary lines throughout Britain, and is designed to replace various tender engines of similar power classification now becoming obsolete. The leading dimensions are as follows:

Cylinders (two), diameter and stroke	17½ in. by 26 in.
Wheels, coupled, diameter	5 ft. 3 in.
Wheels, pony truck, diameter	3 ft.
Wheelbase, coupled	15 ft. 4 in.
Wheelbase, total engine	24 ft. 1 in.
Wheelbase, engine and tender	46 ft. 11¾ in.
Heating surface:	
Tubes	932·9 sq. ft.
Firebox	118·4 sq. ft.
Total evaporative	1,051·3 sq. ft.
Superheater	190 sq. ft.
Grate area	20·35 sq. ft.
Free flue area	3·08 sq. ft.
Boiler pressure	200 lb. per sq. in.
Tractive effort	21,490 lb.
Adhesion factor	5·08
Brake per cent., engine and tender	60·7
Weight of engine in working order	57 tons 10 cwt.
Weight of engine and tender in working order	99 tons 13 cwt.
Minimum radius curve (with specified gauge widening)	4½ chains

The boiler, which is the same as that used on the tank version, follows closely the design of the former G.W.R. Standard No. 2 boiler used on the 5100, 8100 and 5600 Classes. The steel and copper flanged plates for the firebox are common to both designs but the barrel is 5$\frac{13}{16}$ in. shorter. It consists of two rings, the second of which is tapered, the outside diameter being 4 ft. 5 in. at the front and 5 ft. 0$\frac{1}{2}$ in. at the firebox end. Both barrel rings are made from high-tensile steel plate $\frac{1}{2}$ in. thick. The smokebox tubeplate is of the drum-head type $\frac{5}{8}$ in. thick and there are 18 large fire tubes 5$\frac{1}{8}$ in. diameter outside by 7 s.w.g. thick, and 145 small tubes 1$\frac{5}{8}$ in. diameter outside by 12 s.w.g. thick. The length between the tubeplates is 10 ft. 10$\frac{1}{2}$ in.

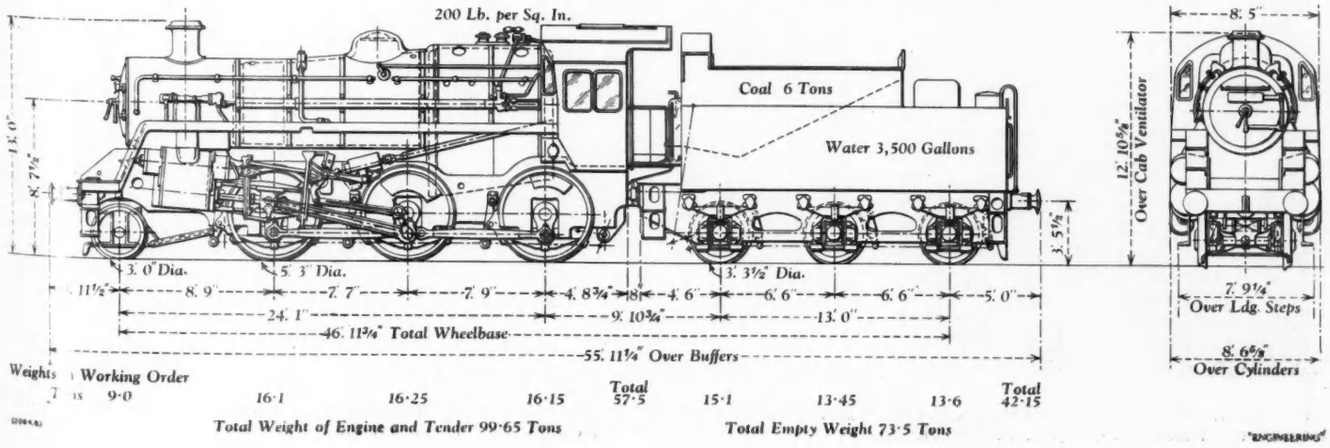
The firebox is of the Belpaire type, 7 ft. long at the bottom and with an outside width of 4 ft., giving a grate area of 20·35 sq. ft. The steel outer wrapper plate and the copper inner wrapper plate are both $\frac{5}{16}$ in. thick. The throat and back plates are vertical, the former being $\frac{5}{8}$ in. thick and the latter $\frac{5}{16}$ in. thick; the copper tubeplate is $\frac{7}{8}$ in. thick. All the firebox waterspace stays are made of Monel metal fitted with nuts inside the firebox, while the roof, longitudinal and transverse stays are of steel. The lagging of the boiler and firebox consists of asbestos mattresses. A rocking grate and a self-emptying ashpan are fitted, the details wherever possible being the same as those on other standard classes. The boiler mountings, regulator, clack valves, manifold and smokebox details are the same as those used on the tank version.

FRAMES

The engine frame, as on previous British Railways standard locomotives, is adequately stayed both horizontally and vertically, while the boiler securing arrangement, the spring gear and the method of staying the axlebox guides are similar to those obtaining on other classes. The wheel arrangement is the same as on the tank version but without the trailing pony truck. Other similar design features include the axleboxes, axlebox guides, lubrication, cylinder-cock and sanding arrangements. The cab layout follows closely that of the other standard tender engines. The two cylinders are of cast steel with cast-iron liners and are the same as those used for the tank version. Piston valves nominally 10 in. in diameter are provided, the rear heads being $\frac{1}{8}$ in. smaller in diameter for ease of insertion and removal. They are operated by Walschaerts valve gear giving full-gear travel of 6$\frac{33}{64}$ in. at a cut-off of 75 per cent. The steam lap is 1$\frac{1}{8}$ in. and the lead is $\frac{1}{4}$ in. The whole gear, with the exception of the reversing shaft and screw, is identical with that of the tank engine. Skefko self-aligning ball bearings are fitted to the return cranks.

The leading pony truck is of standard design. the side play being controlled by helical springs, The tender is the standard B.R.2A type with six tons of coal and 3,500 gallons of water, and although smaller it follows the pattern used for the Classes 6 and 7, 4-6-2 and Class 5, 4-6-0 locomotives. It runs on axleboxes fitted with Timken taper-roller bearings.

* Articles on the first ten standard classes have appeared in ENGINEERING as follows: 4-6-2 Class 7, vol. 171, pages 126 and 341 (1951): 4-6-0 Class 5, vol. 171, page 528 (1951); 4-6-0 Class 4, vol. 171, page 752 (1951); 2-6-4 Class 4 tank, vol. 172, page 138 (1951); 4-6-2 Class 6, vol. 173, page 108 (1952); 2-6-2 Class 3 tank, vol. 173, page 698 (1952); 2-6-0 Class 4, vol. 175, page 12 (1953); 2-6-0 Class 2, vol. 175, page 217 (1953); 2-6-2 Class 2 tank, vol. 176, page 348 (1953); and 2-10-0 Class 9, vol. 177, page 158 (1954).



ENGINEERING EXHIBITS AT THE B.I.F.

The machines, etc., illustrated on this page, which were exhibited in the Engineering and Hardware Section of the British Industries Fair, are briefly described on the opposite page.

Fig. 9 Tube-straightening machine for tubes between 1-in. and 4-in. outside diameter. Bronx Engineering Co., Ltd.

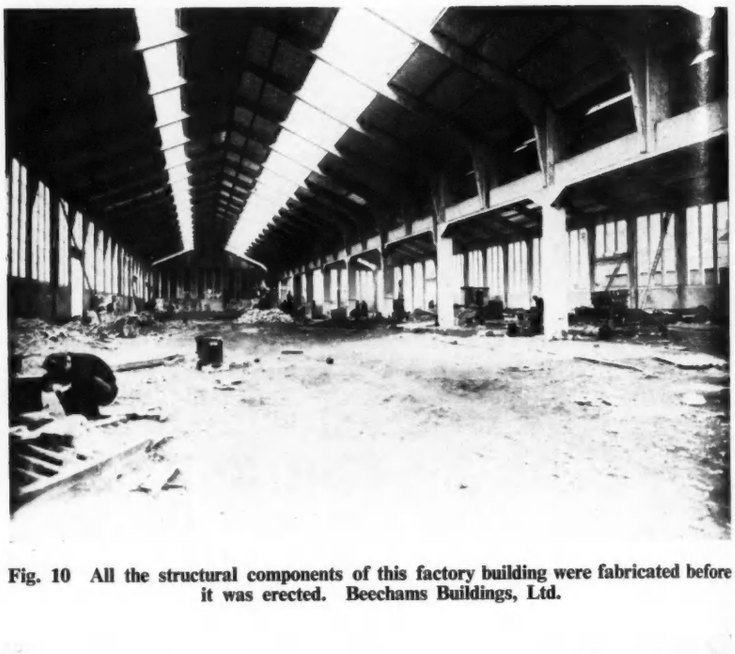


Fig. 10 All the structural components of this factory building were fabricated before it was erected. Beechams Buildings, Ltd.

Fig. 11 Combination decoiler and straightener, which can flatten sheet metal at the rate of 1,500 in. per minute. The ramp at the front facilitates loading. Humphris and Sons, Ltd.

Fig. 12 Onions model 3-4 scraper for fast digging and loading behind tractors with a minimum drawbar pull of 6,000 lb. The scraper is operated by a cable-control unit. Jack Olding and Co., Ltd.

Fig. 13 Detachable track for commercial and agricultural vehicles. Bates Bros. (S.M.W.), Ltd.

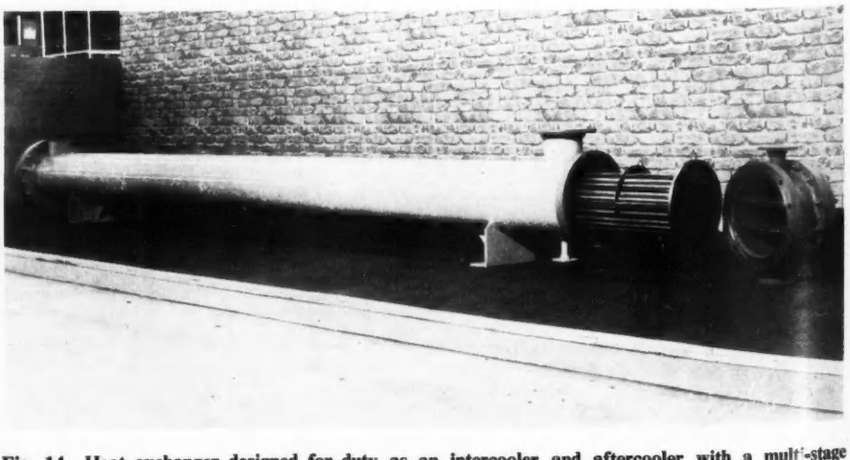


Fig. 14 Heat exchanger designed for duty as an intercooler and aftercooler with a multi-stage gas compressor. Wellington Tube Works, Ltd.

ENGINEERING EXHIBITS AT THE B.I.F.

Concluded from page 635

TUBE-STRAIGHTENING MACHINE

The tube-straightening machine shown in Fig. 9 was exhibited by the Bronx Engineering Company, Limited, Lye, Worcestershire. It has been designed for precision straightening of steel tubes between 1-in. and 4-in. outside diameter. The design comprises two driven work rolls and five opposed pressure rolls disposed vertically, which ensures that the tube is always supported on the work rolls. This arrangement facilitates the insertion of tubes into the nip of the rolls and gives a pass-line which is constant for all tube sizes. Each driven work roll is independently driven from a 15-horse-power slip-ring motor. V-ropes link the drive from the motors to the gearbox and universal mill-type couplings and spindles transmit the drive to the rolls. The couplings can be quickly disconnected when the rolls require removing for redressing. The machine is of steel construction and the frame is a welded fabrication. For straightening light-gauge non-ferrous tubes the machines are fitted with a drive which does not mark their surface. Other machines of this type for straightening all sizes of tubes are being produced by this company and special-purpose machines which make use of standard roll units are also available.

PREFABRICATED INDUSTRIAL BUILDINGS

A prefabricated building having a span of 15 ft., 20 ft. to eaves by 30 ft. long dominated the stand of Beechams Buildings, Limited, Shipton-on-Stour, Warwickshire. In appearance it resembled a church and it was erected to provide an example of the type of construction which this company carries out. The illustration on page 666 (Fig. 10) shows a prefabricated building erected by them for use as a factory.

The makers claim to be the producers of the largest precast reinforced-concrete spans in Europe. Clear spans of up to 80 ft. are being made. The form of construction which they have chosen permits complete permanent industrial buildings to be designed, factory produced, and erected in the minimum of time. The system is based on the use of the three-pin arch. It makes for structural economy as it has no fixed points of contra-flexture. The makers also state that large industrial buildings have been erected by this method in a quarter of the time taken by traditional methods. The system makes use of a large number of standard units which allow varying sizes of span, height to eaves, differing degrees of thermal conductivity and lighting of the building. Gantries for travelling cranes up to 40-ton capacity can also be incorporated.

The company recently erected an industrial building of some 50,000 sq. ft. with a 60 ft. span measuring 30 ft. to eaves, and having internal columns at 30 ft. centres. The whole structure, including 12 in. walls up to a height of 10 ft. reinforced-concrete glazed-mullion panels above, sliding doors, roof lights, and all foundation work was completed in 4½ months. The building is now in operation as a fettling shop for Sterling Metals, Limited, Nuneaton.

COMBINATION DECOILER

The illustration (Fig. 11) shows the CD-1,000 combination decoiler and straightener which was exhibited on the stand of Humphris and Sons, Limited, of West Quay-road, Poole, Dorset. It is designed for handling large, wide and heavy coils of sheet metal and reducing the handling time normally required in this process. It will accommodate a coil with a maximum diameter of 40 in., varying in width from 4 in. to 16 in. and not exceeding 14 s.w.g.

The ramp, which can be seen at the front of the machine in the illustration, enables the coil to be rolled into position so that it rests on two rubber-covered rollers of Meehanite iron, which support the outside of the coil. Two cheek plates, which are self-centralising and can be controlled by a single handle, act as lateral guides for the coil. The two support rollers are power driven and uncoil the material at a constant speed feeding it to the seven-roll straightener where it is flattened continuously. The material leaves the rolls ready for use in pressing operations. The decoiling rate can be selected to correspond with the press-feed rate. The machine has automatic loop control and retractable wheels are fitted at the front, which allow it to be moved about the shop floor.

Special features of this machine include quick-action " alligator " opening to allow feeding of new coils without alteration to the roll settings. The seven straightening rolls run in needle-bearings, and there are separate pinch rollers and an outgoing transport roller. The starter is interlocked with a micro-switch control, and there is a manually-operated variable speed control.

The maximum weight of coil that can be handled is 1,000 lb. and the de-coiling rate is infinitely variable between 375-1,500 in. per minute. The driving power is provided by a 1½-h.p. electric motor.

OPEN-BOWL SCRAPERS

Three models of the Onions open-bowl scrapers were exhibited by Jack Olding and Company, Limited, Hatfield, Hertfordshire. They are designated 3-4, 8-11 and 15-21 and were produced as result of experience and satisfactory performance gained with the model 12-16 which was introduced two years ago. Fig. 12 illustrates the model 3-4 in use.

The 3-4 is of particular interest since it has been designed for use with light industrial tractors, and is suitable for small scale earth-moving operations encountered in the development of estate roads, building-land clearing, irrigation or soil conservation and other earth moving projects. It is also designed for fast digging and unloading. A high apron lift enables loads to be ejected quickly by the central-thrust tailgate, and is particularly useful for sticky materials. The open bowl gives good stability for operating over rough ground and allows a greater proportion of the scraper's weight to be concentrated over the cutting edge of the bowl for faster digging. It has a stack and heaped capacity of 2·7 and 3·6 cub. yards respectively, and can be operated by tractors of 6,000 lb. drawbar pull. The illustration shows it behind a Fordson Major with Mk. III County full tracks.

The cutting blade is 5 ft. 4 in. wide and the overall width is 6 ft. 1 in. The turning circle is 15 ft. 7 in. The weight of the model 3-4 is about 1 ton 18 cwt.

CABLE CONTROL UNIT FOR TRACTOR

The model 10 cable-control unit, which can also be seen in the illustration, has been designed for use with the Fordson Major tractor and can be used to operate any earthmoving equipment using a ⅝-in. diameter rope. It is compact, reducing the overhang and thereby preserving the balance of the tractor. The swinging point of the rope fairleads have been placed slightly forward of the drawbar pin to prevent stretching the operating ropes of the scraper when turning. It has two drums. The spur reduction gear enables the drums to be set transversely, with the swinging fairleads mounted directly above. The two operating levers are pivoted to move across the tractor to the rear of the driver's seat; they have a short travel and are easy to operate.

The main body of the unit consists of a rigid-steel fabrication with a large flange bolting securely to the rear of the tractor. A top carriage, which is also a fabrication, carries the swinging fairleads mounted on angular-contact bearings, which are adjustable for wear. The rope pulleys are hardened and run on roller bearings. The spur gears run in an oil bath.

The line speed at 500 r.p.m. of the engine is 376 ft. per minute for a full drum and 224 ft. per minute for a bare drum. The weight of the unit is 728 lb.

TRACKS FOR WHEELED VEHICLES

The detachable metal track shown on the rear wheels of the tractor in Fig. 13 is known as the Mudmaster and it is being made under licence by Bates Brothers (S.M.W.) Limited, Reliance Works, Baguley, Manchester. During the exhibition demonstrations were given by a vehicle equipped with this track driving through wet and muddy ground and climbing a small incline.

The links of the track consist of triangular sheet-metal plates pinned together at the base corners. The apex of the triangle is drilled to carry the cross bars of the track which are made from a strip of sheet steel bent along the longitudinal axis at an angle of about 90 deg., as can be seen in the illustration. The triangular plates protect the side walls of the track and crossbars, designed to enable a good grip to be gained on any type of ground, allow normal road wheels to be used for traversing rough ground.

To fit the track it is necessary to lay it in a straight line on the ground and back the vehicle on to the first quarter of its length. The end of the track is then lifted and wrapped round the wheel and bolted through the most suitable hole on the coupling link. It should be a slack fit around the tyre when adjusted correctly. Should a rivet break in one of the links a high-tensile bolt may be substituted. Tracks are at present being made to suit a wide range of wheel sizes for commercial and agricultural vehicles and private motor cars.

HEAT EXCHANGER

Wellington Tube Works, Limited, Great Bridge, Tipton, Staffordshire, were showing a selection of steel and light-alloy drop forgings manufactured by the Stampings Alliance, Limited, Argyle-street, Birmingham, 7, together with their tubular heat exchangers.

The illustration (Fig. 14) on page 666 shows one of a set of ethylene gas coolers designed and produced by the company for duty as inter-coolers and aftercoolers with a multi-stage gas compressor to be installed in a chemical works. The main material of construction is carbon steel and the tubes are of stainless steel.

In our issue of October 2, 1953, we described the company's " Weldex " bled-steam air pre-heaters. One of these was installed in the Orient liner Orsova, which has now successfully completed her sea-going trials.

TELEVISION EQUIPMENT

IMPROVED IMAGE ORTHICON CAMERA AND FILM PROJECTOR

On May 5, the Marconi Wireless Telegraph Company, Limited, Chelmsford, gave a demonstration of three new items of television equipment: a 4½-in. Image Orthicon tube developed by the English Electric Valve Company, Limited; a complete camera equipment designed specifically for this new tube which will, however, also accommodate the present 3-in. tube; and a flying-spot teleciné equipment for transmitting either 16 mm. film or 2 in. by 2 in. slides. The demonstration was given at the Great Baddow (Essex) Laboratories and a closed-circuit television system with several receivers was used to enable the whole party to observe it simultaneously.

PICK-UP TUBE

The 4½-in. Image Orthicon pick-up tube has many advantages over the 3-in. tube. It gives a better tonal gradation and cleaner picture. It is claimed that the resolution is such that it provides a far better picture than any existing television system is capable of transmitting. The tube is shown in Fig. 1.

Halo, edge effect and ghosting are virtually non-existent. ("Halo" is a black area surrounding picture highlights. "Edge effect" is sometimes seen as a thin white line produced immediately to the right of, and below, a sharp black-to-white transition. "Ghosting" occurs when a spurious second image is seen superimposed upon the picture.)

The new tube is more sympathetic to changes of lighting, which means that the change from dark interior to bright exterior scenes can be made by the camera without major adjustments. This facility allows more freedom for lighting effects. Unlike the 3-in. Image Orthicon, which requires skilled adjustment and operation of camera controls for maximum performance, the new tube is stable in performance from day to day and from tube to tube. Hence, once it has been set up, it can be operated with little or no adjustment. It has been designed for use with the same lenses as the 3-in. tube. The latter will remain in production as it is still better for use underwater or in very poor lighting conditions.

MAGNIFIED IMAGE AREA

For descriptive purposes the tube may be divided into three sections: the image section containing the photo-cathode, image-focusing electrodes and target; the scanning section; and the gun and multiplier section.

The image section has been made longer than that of the 3-in. version; within this section is incorporated an arrangement whereby an electron optical magnification of the image takes place. The area of the image on the target is approximately three times that of the optical image projected upon the photo-cathode, the magnification being carried out by a combination of electrostatic and electromagnetic fields. Advantage is also taken of the longer path between photo-cathode and target to provide two loops of focus. This eliminates electron ghosts. The target is manufactured in a similar fashion to that of the 3-in. tube. The spacing has been chosen for freedom from microphony while retaining a satisfactory grey-scale and life.

The scanning section of the tube is bounded by the wall coating, which serves as the focusing grid for the electron beam. The target end of the wall coating is closed by a fine electron-permeable screen, termed the field mesh. It is effective in eliminating edge effect.

The gun-multiplier assembly is basically the same as that employed in the 3-in. tube. The five-stage electron multiplier is mounted coaxially with the simple three element gun. Several minor modifications have been introduced to ensure that saturation does not occur owing to the increased beam current required.

Connections to the tube are made through a standard 14-pin base and a special 8-point shoulder socket.

CAMERA SIMPLE TO OPERATE

The Mark III Image Orthicon camera equipment can be used in conjunction with either the new 4½-in. pick-up tube or the 3-in. version currently in use. Fig. 2 is a general view from the front. It can be used with existing Mark II equipment, and existing lenses on Mark II cameras can be easily converted for use with the new Mark III. The entire equipment has been designed to provide simplicity of operation. Its lens turret will permit any combination of lenses from 2 in. to 40 in. focus to be mounted simultaneously. Hand control of both focus and of lens selection is provided, but remote control facilities are also available.

A feature of this camera is the provision of an improved type of variable light control. This consists of two discs mounted in the camera turret, one carrying a number of fixed filters any one of which can be selected by the camera operator and the other consisting of a circular glass disc, the light transparency of which varies as the disc turns. This disc is remotely operated from the camera control position and thereby provides a fine and smoothly varying control of the amount of light which reaches the pick-up tube. This is an improvement over earlier methods of light control, since the depth of focus of the lens can be pre-set by using the iris diaphragm and will remain fixed. By using a low-temperature winding focus coil and electronic temperature control of the yoke heater winding, the necessity for a cooling blower is eliminated, giving a silent equipment.

The same camera is employed in both studio and mobile channels. The camera control chassis and picture and waveform monitor chassis are mounted together to form a single camera control and preview monitor position and are fitted in a studio console housing or mobile case. As the same chassis are used for both the studio and the mobile applications, maintenance personnel need only familiarise themselves with one equipment and the advantage of simple convertibility between studio and outside broadcast use is gained. The stocking of spares is also simplified.

BUILT IN THREE SECTIONS

Size and weight have been kept to a minimum consistent with rigidity and strength. The camera is built to give maximum reliability in operation, and is shower proof. It is built in three main parts – the camera proper, viewfinder and lens turret – and for transport purposes these can be carried separately. Carrying cases are provided for the turret and lenses, and the camera is designed to fit on a standard shock-absorber mounting. Assembly is carried out simply and quick-release devices permit the rapid removal of individual units.

The Image Orthicon tube together with its deflection and focus coils and associated vision amplifier – which are mounted on the yoke carriage assembly – form one compartment at the left-hand side (viewed from the front of the camera). The vision amplifier is built on to a plug-in chassis. The yoke carriage runs on ball-bearings and may be locked in position (as may be required when "zoom" lenses are used or during transit). The deflection coils may be "rocked" $\pm$ 45 deg. to give tilted pictures – a useful facility in some productions. The tube is fitted from the front of the camera.

The centre compartment contains the lens-turret rotating mechanism, which can be motorised if desired so that lens changing can be controlled from the camera-control unit. This might be required for entirely remotely-controlled operation. For manual use a turret rotating handle is provided at the rear of the camera; one revolution of the handle will bring another lens into position. This operation takes approximately one second.

On the other side, three units plug into a main chassis, which is itself hinged, and so ready access is afforded for servicing purposes. These sub-assemblies comprise the line scan generator, extra high-tension generator and scan protection circuits, blanking mixer, focus modulator, and vision amplifier output stages. High efficiency scanning systems are used, and the need for linearity controls is eliminated by the application of negative feedback. A neon indicator shows the correct operation of the scan protection circuits. Pre-set controls, fuses, main-cable

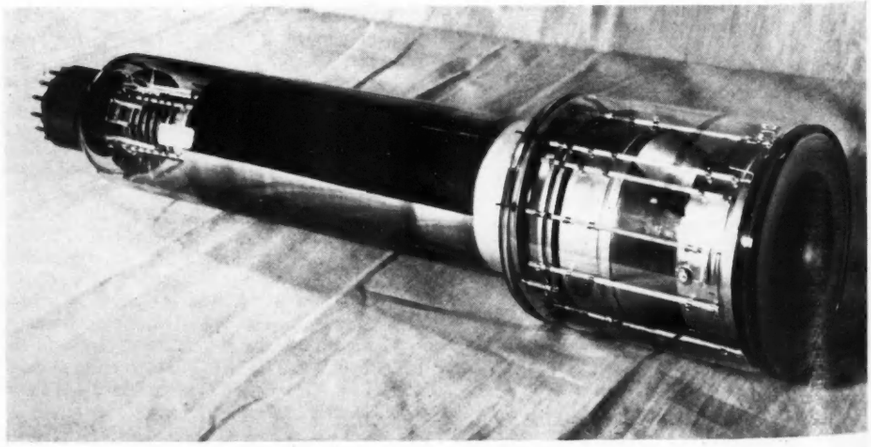


Fig. 1 The 4½-in. Image Orthicon pick-up tube. Halo and ghosting have been almost eliminated and tonal gradation improved.

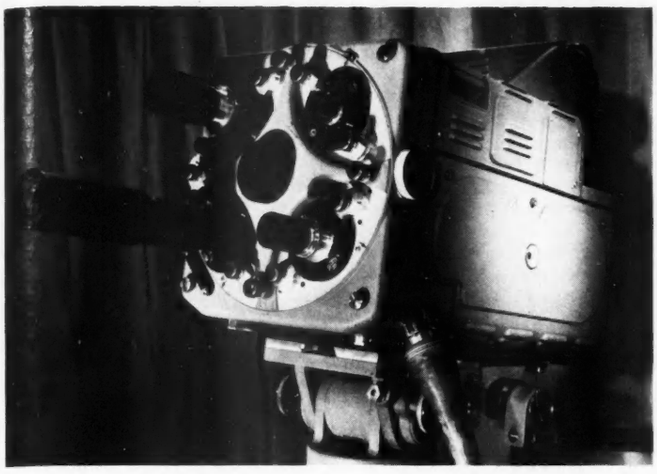


Fig. 2. The Mark III camera can use either the new 4½-in. or the old 3-in. tube. Operations have been simplified and complete remote control can be used.

plug and mains transformer are also accessible from this side of the camera.

The talk-back chassis forms the rear panel of the camera which also carries jacks for connecting the cameraman's headset and microphone and two additional headsets and headphones. A microphone switch and volume control are provided. The controls on the camera are located behind a hinged door, which is open when the camera is in operation and carries a clip for holding a script and a small note tablet. The turret rotating handle is at the back of the camera below these controls, and the panning handle may be fitted into either side. Focusing is carried out by means of a handle located on the right-hand side (relative to operator) of the camera, movement of which operates a lever mechanism that causes the yoke assembly to travel. One model permits focusing to be carried out from the left side. Two cue lamps are mounted, one at the front and one at the rear of the camera. Provision is made for fitting a panning handle on the body of the camera, which facility is of particular value when heavy lenses or " zoom " lenses are in use. The camera has a V-block at the base and this is adjustable fore and aft to give a proper balance of weight with different lens combinations. The camera cable connector is small in size and extremely flexible, and thereby creates less drag when panning. Two carrying handles are located in each side of the camera.

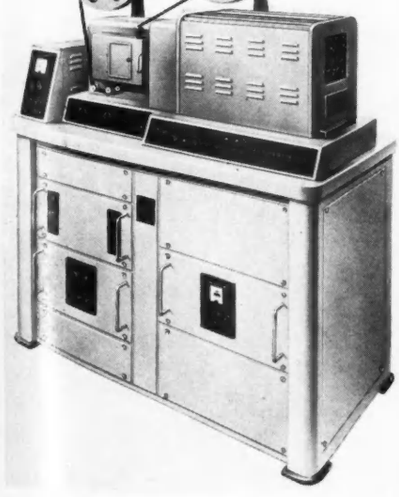


Fig. 3 Teleciné projection equipment for either 16 mm films or 2 in. by 2 in. slides. The turret for the slides is on the far side. Film frames are changed during the field-blanking period.

ELECTRONIC VIEWFINDER

The top of the camera is recessed to take the viewfinder which is mounted on a counterpoise suspension, permitting flexibility in operation and enabling the viewfinder to be set in any desired position. This facility is important in cases when the camera position needs to be close to the ground or directed down from a parapet.

The viewfinder contains a 5-in. picture tube and associated circuits fitted on to a hinged frame. It is an easy matter to change a tube and this may be carried out when the viewfinder is in position on the camera. A viewing hood fitted with a detachable plastic lens having a magnification of two, clips on to the end of the unit. All controls are arranged around the hood, and are edge type; no linearity control is required. Six Perspex indicators are arranged along the lens edge to give cueing information to the cameraman. These indicate which lens is in use (four indicators) and whether the camera is " on the air " or switched to preview.

Interconnection between camera and viewfinder is made by means of two flexible plug-in leads. The viewfinder is removed from the camera by means of a quick-release device. It is sufficiently sensitive to enable corrections to be made before they become visible on a broadcast receiver.

Models of the complete equipment are available for use on 405, 525 or 625 line systems, using either a 50-cycle or 60-cycle supply.

TELECINÉ EQUIPMENT

The third item demonstrated was a teleciné equipment designed to provide high-quality television pictures from 16-mm. film or 2 in. by 2 in. slides. The film frame is drawn down during the field-blanking period of the television system, the motion taking about 1·3 microseconds. This has advantages over optical blanking systems. The projector and scanning units are shown in Fig. 3 with the power supplies below.

The mechanism is driven from an electric motor which is arranged to rotate in synchronism with the frame repetition rate of the television system. The motor operates at 3,000 r.p.m. for 405-line and 625-line television systems and at 3,600 r.p.m. for 525-line systems. It drives a shaft on the end of which is mounted a rotating arm carrying a pin which engages with a slotted link mounted on the end of another shaft. The link and pin are so located that the rotating motion of the driven shaft is non-linear; in other words, it rotates steadily during part of its revolution and is then rotated very much more rapidly for the remainder of one complete revolution. This shaft is used to drive another identical set of links and this second set of links is fitted to a cam which actuates a claw. The claw engages with the perforation of the film in the usual manner. In this way the film is accelerated, pulled down rapidly, decelerated and brought to rest within the required time. Insertion and withdrawal of the claw from the film is governed by a further system of links and another cam which are coupled to the same motor.

The whole link system is mounted in a cylindrical steel housing which serves to retain the lubricating oil and at the same time to reduce noise to a reasonably low level. When the equipment is used on a television system having a field repetition rate of sixty cycles the projector is supplied with a " 3/2 " pull-down motion. Under these conditions successive film frames remain in the projector for periods of three fields and two fields, respectively. The 60-cycle television field rate is thereby converted to the standard 24-cycle film frame repetition rate.

REMOTE CONTROL

The light from the scanning raster is focused on to the film by a 1-in. f/1·4 specially corrected lens whence it passes, through a condenser, on to a nine-stage photo-multiplier. The video signal from the photo-multiplier is fed into a two-stage head amplifier and thence out to the main video amplifier incorporated in the flying-spot scanning unit at an impedance of 75 ohms.

The turret slide scanner will accommodate eight standard 2 in. by 2 in. transparencies located around its periphery. The unit is motor driven, the appropriate slide being selected by one of eight buttons on the control units. The unit will rotate to any selected slide by the shortest route. The unit contains an optical system and head amplifier identical with that of the projector. A motor-driven surface-silvered mirror works in conjunction with the slide projector. This mirror deflects the light from the scanning raster into the slide scanner optical system when slides are being televised.

The flying-spot head contains the controls for the use of the film operator, together with intercommunication facilities. Once the equipment has been set up initially the operator has only to change film and replenish the slide magazine. Facilities are provided to lock-out the projector and turret slide scanner controls on other control positions at this unit, so that no accident can occur while the film is being re-threaded.

Models are available for any of the three line systems, 405, 525, or 625. The entire apparatus can be completely remote controlled, including the changeover from film to slide and vice versa. Either positive or negative films can be accommodated. In addition, by a comparatively simple exchange of units, the equipment can be used to made films from television signals.

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WELDING SHOP EQUIPMENT

Exhibition of Mechanised Plant

A private trade exhibition of Yates mechanised welding-shop plant is to be held from Monday, June 21 to Wednesday, July 14, at 336-338 High-road, Wembley, Middlesex. The equipment to be displayed will include manipulators, rotators, columns with elevating arms to carry automatic welding heads and portable power units. The makers of Yates welding-shop plant are the Surrey Tool Development Co., Ltd., 156-158 Dalston-lane, Hackney, London, E.8.

HEAVY ALLOY IN FULL PRODUCTION

USES OF A HIGH-DENSITY MATERIAL

Before the second World War, the research laboratories of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, succeeded in developing a series of alloys of high density, 16½-17½ grammes per cc. intended, in the first place, as a better shielding material for use in radium-beam therapy than the lead which had up till then been generally used. It was soon learned that there were many other applications for heavy alloy, notably in the aeronautical and instrument fields. Until recently the manufacture of G.E.C. heavy alloy has been carried out at a pilot plant at the research laboratories, and in the post-war years output has been severely restricted by the availability of tungsten, the principal constituent. Now, however, there are no limitations on the use of tungsten, and the manufacture of G.E.C. heavy alloy has been transferred from the pilot plant to the Osram-G.E.C. metals factory at Wembley, where it is in full production.

Tungsten, with a density of 19·4 grammes per c.c. is not suitable for direct application as a shielding material since, with a melting point of 3,400 deg. C., it is virtually impossible to cast large masses. As an engineering material it is unsatisfactory since it cannot be machined. The G.E.C. research laboratories, however, discovered that when powdered tungsten is alloyed with small quantities of powdered copper, nickel and iron, a dense alloy can be obtained with tensile properties comparable to that of mild steel and which can be readily machined and brazed. The metal powder, moreover, when pressed, retains its shape throughout the sintering operation, and shrinks to a pre-calculable degree, so that it is possible, in the case of simple components at least, to pre-form them to their final shape.

PROPERTIES

G.E.C. heavy alloy is resistant to atmospheric corrosion but it can be given any of the usual finishes such as nickel, chromium or cadmium plating. The average properties of G.E.C. heavy alloy, when tested in accordance with the provision of B.S. 18 : 1950, are as follow : specific gravity, 16·5 to 17; approximate weight, 0·6 lb. per cub. in.; tensile strength, 42 tons per sq. in.; yield point, 38 tons per sq. in.; Brinell hardness number, 290; and coefficient of expansion over the range 20 deg. to 420 deg. C., $5·6 \times 10^{-6}$.

A new series of alloys is under development, with densities up to 18 grammes per c.c. and higher, with properties comparable to those of the existing alloy listed above, and which can also be drilled, tapped, turned, ground and machined. An alloy of higher elongation, with no corresponding decrease in tensile strength, is also under development and will soon be available in sheets of limited size.

MANUFACTURING PROCESS

The metal powders are prepared and tested to a rigid specification for purity and particle size. After weighing out the constituents, the powders are mixed in a Beken mixer to ensure that they are evenly distributed. A paraffin wax binder is then added and further mixing takes place in the Beken mixer and finally in machines of the food-mixing type. The powder is then sieved ready for pressing.

The dies used in the power presses are designed to allow for the uniform shrinkage which will take place during sintering. They are of robust construction to resist the considerable side pressures developed during pressing. Most of the presses used are of the automatic ejection type. After forming in the press, the compacted components are removed to pre-sintering furnaces.

In the pre-sintering electric furnaces, the components are heated in a hydrogen atmosphere at 925 deg. C. for a prolonged period (of the order of 16 hours, but depending on the material) during which the wax binder melts. After cooling, the component, now in the "green" state, can be handled readily, and if the final contours required are more complex than can be acquired in the die-forming operation, it can be machined as necessary.

The final sintering operation is carried out at 1,450 deg. C. in a hydrogen atmosphere over a period of about 12 to 14 hours. Larger components are fired in G.E.C. electric muffle furnaces, as shown in Fig. 1, whereas continuous tube furnaces are employed for smaller pressings, which are ejected, after sintering, into cooling water jackets. During the sintering process the alloying metals, which have lower melting points than tungsten form a "liquid" matrix and the compact shrinks by nearly 20 per cent. with a corresponding weight increase of 10 to 12 grammes per c.c.

The sintered components can then be machined as desired, preferably with tungsten-carbide tools, after which inspection for dimensional accuracy and density is carried out.

AERONAUTICAL APPLICATIONS

In the aircraft industry, G.E.C. heavy alloy has for many years been used for mass-balancing control surfaces. Heavy-alloy mass balances can generally be contained within the wing, fin and tail plane, thus eliminating drag completely. The Canberra, Attacker, Swift – and in fact most present-day aircraft – employ G.E.C. heavy alloy for this purpose. When heavy alloy becomes available in the form of sheet, the air-craft designers' task will be still further simplified.

G.E.C. heavy alloy was employed in the *g*-restrictor, made by British Messier, Limited, Gloucester. This unit warned the pilot when a critical vertical acceleration on the aircraft was reached by imposing a resisting load on the control column. Should the pilot ignore the initial resistance and impose a greater vertical acceleration on the aircraft, the *g*-resistor developed sufficient force to move the control against the pilot's force and thus reduce the vertical acceleration. In principle it comprised a pump circulating a hydraulic fluid at 3·7 cub. in. per sec. in a closed system past a valve which was normally held open by a strong spring. A critical vertical acceleration, however, caused a 2-lb. weight to overcome the resistance of the spring on which it rested, closing the valve and thus setting up a pressure head in the jack which opposed the force exerted by the pilot on the control column. The cut-in (initial movement of the weight) is 1·7 G.

It would not have been possible to make the weight from lead because of the electrolytic action between the hydraulic fluid and the component. Nor was steel a practicable alternative, since it would occupy twice the space, increasing the size of the chamber in proportion. G.E.C. heavy alloy overcame these problems.

FLYWHEEL FOR BRAKE UNIT

The Maxaret automatic brake control unit made by the Aviation Division of the Dunlop Rubber Company, Limited, provides a further example of the value of a material which can offer a high moment of inertia in the minimum space. The unit itself is designed to provide the most efficient braking torque throughout the landing run of an aircraft. It consists of a flywheel and drum within a rubber-tyred shell, and a valve mechanism. It is mounted on the torque plate of the brake with the rubber tyre of the shell in contact with, and driven by, the inner rim of the wheel flange.

Ball bearings separate the perimeter of the drum and the inner rim of the flywheel. Normally the drum drives the flywheel, by contact of the flywheel spoke with two segmental bosses, the edges of which contact the spoke and permit 60 deg. of independent angular movement between the drum and the flywheel. Contact in the first place in the static condition is brought about by a main spring which pulls the drum round to the flywheel. During deceleration of

Fig. 1 After a pre-sintering operation, the components are sintered in electric furnaces at a temperature of 1,450 deg. C. Considerable shrinkage takes place, with a corresponding increase in density.

Fig. 2 G.E.C. heavy-alloy flywheel for Dunlop Maxaret automatic brake control unit.

the landing wheel the flywheel, having a minimum frictional contact with the drum will, owing to its energy, advance 60 deg. against the pull of the clock spring and drive the drum. This relative movement actuates a valve mechanism which releases the pressure in the brake and closes the brake pressure supply until the wheels have regained speed. Provision is also made for holding the brakes in the " off " position for a maximum period of 3·5 seconds in the event of the aircraft " bouncing " after the brakes have been applied.

In cases where the space between the bogie wheels of an aircraft or between the wheels and other equipment is restricted the use of G.E.C. heavy alloy for the flywheel is clearly advantageous. Lead occupies too much space, and the alternative would be to use a small flywheel with a low energy potential as a sensing unit only, controlling the brakes by electro magnetic gear, thus introducing additional complication.

The General Electric Company supplies a sintered heavy-alloy blank made to close limits, illustrated in Fig. 2, so that the Maxaret flywheel can be produced with the minimum of machining. When it is received, it is machined all over, has a ball race ground in it and the thin web machined away leaving a single diametral spoke. The material is amenable to all these operations and is machined to a tolerance of 0·003 in. It is hard enough to form a ball race of $\frac{3}{32}$ in. diameter steel balls on each side of the central web, and is driven, through bosses in the central web, at speeds up to 8,000 r.p.m.

GYROSCOPIC INSTRUMENTS

The designer of a gyroscopic movement must provide a maximum mass density at as large a radius as possible within the allowable limitations on physical dimensions and overall weight. The Sperry Gyroscope Company, Limited, Brentford, have found that their electric gyro horizon, which provides a pilot with direct indication of his altitude in the lateral and longitudinal planes, has an increased efficiency since bronze or brass rotors were replaced by rotors of G.E.C. heavy alloy. The instrument employs a three-phase squirrel-cage induction motor with the squirrel-cage rotor spinning on a vertical axis around the stator windings. The squirrel cage is housed in a cup of G.E.C. heavy alloy (Fig. 3) to which it is bonded with Araldite. This method of construction ensures that the weight of the rotor is concentrated as near to the periphery as possible, and therefore provides the maximum inertia.

Tensile strength is an important requirement in this application, where the 1·87-in. diameter rotor must undergo a speed test at 30,000 r.p.m. without fracture. Machinability is also an important requisite because the blank supplied by the General Electric Company is machined in the Sperry works to a tolerance of 0·006 in. A hole is also bored in the bottom of the blank for the shaft of the rotor.

In the air-driven artificial horizons and the gyroscopic direction indicators made by Smiths Aircraft Instruments, Limited, Cheltenham, G.E.C. heavy alloy is used in a similar fashion as a tyre on the gyro rotors. The normal operating speed of the rotors, at 3½ in. Hg. suction, is 15,000 r.p.m. for the artificial horizon and 18,000 r.p.m. for the directional gyro. Since the material permits mechanical working, dynamic balancing is carried out on the rotors by drilling out portions of the heavy alloy as required. Balance of the order of 1 milligramme-centimetre is obtained in this way.

Again, since space is always a major consideration in the design of aircraft instruments, the material is also used in Smith artificial horizons in the form of a ¼-in. diameter ball, operating in a ball cup. G.E.C. heavy alloy achieves the desired pendulosity of the system with a relatively small ball.

HIGH-SPEED CAMERAS

Another dynamic application for G.E.C. heavy alloy is in the H.S.300 high-speed camera made by W. Vinten, Limited. This 35-mm. camera is capable of speeds up to 275 frames a second. At all speeds the picture must be steady, so that perfection of balance in the moving parts is of the highest importance. G.E.C. heavy alloy has therefore been employed to balance the crankshaft, since it was the only practicable material to give sufficient weight in the available space.

Other applications for G.E.C. heavy alloy are as a material for the arcing contacts of oil-immersed heavy-current circuit-breakers, where it has proved very resistant to the destructive action of the arc. It is also widely used for balancing the moving parts of all kinds of machines, from the crankshafts of racing cars to variable-pitch propellers. It has been similarly used in centrifugal clutches and vibration dampers.

Fig. 3 The rotor of the Sperry electric gyro horizon consists of a squirrel cage housed in a cup of G.E.C. heavy alloy.

* * *

FILM ON PRODUCTION OF RAILWAY MATERIALS

A sound film dealing with the manufacture of railway materials, produced for the Steel, Peech and Tozer branch of the United Steel Companies Limited, 17 Westbourne-road, Sheffield, 10, by Wallace Productions Limited, was shown in London recently. The object of the film, which is entitled " Steel Ride," is to give railway engineers, operatives and others an insight into the methods employed for producing wheels, axles, springs and locomotive tyres. Introductory sequences in the open-hearth steel melting shop lead on to views of the casting of ingots and their being broken into blocks preparatory to being pressed into wheel forgings. The complete operations of forging, rolling, dishing, heat treatment, quenching and machining of the wheels is then shown. It may be recalled that we gave an illustrated description of the firm's railway wheel mill on page 515 of vol. 173 (1952). The production of axles by hammer-forging, heat treatment, quenching and machining and the pressing of the wheels on to the axles is then shown, as are also the general basic operations of the manufacture of springs and, finally, of locomotive tyres. Copies of the film are available on loan, and application should be made to the public relations officer of the United Steel Companies at the address given above.

* * *

LONDON EXHIBITION OF FILTRATION AND SILENCING EQUIPMENT

A representative selection of their wide range of filtration and silencing equipment will be exhibited by Vokes, Limited, at the Kensington Palace Hotel, De Vere-gardens, London, W.8, from to-day until next Thursday, May 27.

Apparatus on view will include a rock-drill dust trap; a model of a grading cyclone; and a small dust-collector unit, incorporating tube cyclones and using mechanical agitation of the filter envelopes. A number of exhibits will be supplied by the firm's subsidiary companies.

Attendance on the opening day will be restricted to executive officials and technicians specially invited, but the general public will be admitted during the remainder of the exhibition. Further particulars may be obtained from the company's head office, Henley Park, Guildford, Surrey.

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BIRMINGHAM EXHIBITION OF DUST FILTERS

Arrangements have been made by Air Control Installations, Limited, Ruislip, Middlesex, to hold an exhibition of their recently-developed dust filters and other manufactures at the Imperial Hotel, Temple-street, Birmingham, 2, on Tuesday and Wednesday, June 1 and 2.

The exhibition will be open from 3.30 to 7 p.m. on June 1 and from 11 a.m. to 7 p.m. on the following day. Admission will be obtainable on presentation of a business card or an invitation ticket issued by the company.

Reference to the firm's Dusgard system of external dust control was made on page 606 of our issue of May 7.

Labour Notes

A.E.U. IN CONFERENCE

A wide variety of subjects, ranging from the suitability of girls for indentured apprenticeships to the advisability of supplying arms to Germany, were discussed at the two-week conference of the Amalgamated Engineering Union's national committee at Blackpool, which ended last Friday. The conference opened with an address by the union's President, Mr. Robert Openshaw, on May 3, to which reference was made on page 639.

During a debate on May 4, on holidays with pay, some of the 52 delegates complained about engineering employees who did not take full advantage of the annual holidays to which they were entitled and which the union had striven so hard to obtain. One union official asserted that about four-fifths of the employees at a factory he had in mind had failed to take all the 16 days which were their due.

In spite of these pleas, the conference rejected a motion that payment for holidays should not be made to workpeople who neglected to take them. Another resolution, however, which directed the union's executive council to negotiate with the employers for amendments to the industry's agreement on holidays, so as to ensure that employees had no option but to take their full 16 days' leave, was duly approved by the delegates.

NEW DISPUTES AGREEMENT SOUGHT

During the consideration of a composite resolution on provisions for avoiding disputes in the industry, delegates complained that grievances, whether workshop problems or wage questions, took too long to settle. It was alleged, also, that the existing procedure, which is based on a thirty-year-old agreement known as the York memorandum, operated too often in favour of the employers.

This memorandum provides that disputes between workpeople and managements shall be dealt with first at factory level and, should there be failure to agree, that the difficulties shall be referred progressively to local and national headquarters before any strike action takes place.

Rejection of the memorandum might be deemed to provide opportunities for strikes in support of factory agreements and would thus tend to increase the already extensive powers of shop stewards.

The resolution instructed the executive council to end the existing agreement immediately, to initiate a publicity campaign regarding the union's scheme for a central joint council for the industry, and to summon another meeting of the national committee for the consideration of further action. It was finally approved with only two dissentients.

REVISION OF THE INDUSTRY'S WAGE STRUCTURE

At a subsequent session, proposals for launching a new claim, for a general advance of 10 per cent. on existing wage rates, were put forward and defeated. In their place, the delegates decided to pursue the plan which the union drew up some time ago for a comprehensive wage structure in the engineering industry.

The principle of a simplified wage structure has already been accepted by the other 38 organisations affiliated to the Confederation of Shipbuilding and Engineering Unions. Now, presumably, the more detailed scheme of the A.E.U., which has the approval of its executive council, will be placed before the Confederation, in the hope that negotiations will be re-opened with the employers on this question in the course of the next few months.

The union's plans provide for the division of the industry's employees into six grades. The starting rate, for labourers, would be £6 18*s.* 4*d.* a week, rising, through groups of semi-skilled employees, to a rate of £8 2*s.* 4*d.* for skilled men. In addition, there would be a higher grade of specially-skilled craftsmen, who would be paid £8 10*s.* 4*d.* a week. These rates would provide for advances ranging from 13*s.* 6*d.* a week for labourers to 17*s.* 6*d.* a week for skilled men.

A number of criticisms were directed against the union's leaders during this debate. They were condemned for accepting the report of the engineering court of inquiry, for postponing the restrictions on overtime and piece-work, and for agreeing to an increase of less than the 15 per cent. demanded.

Members of the executive council replied that the employers could not reasonably have been expected to accept the full claim, that support for the restrictions would have been doubtful, and that a ballot of the members would have resulted in acceptance of the 6 per cent. increase.

INTER-UNION RELATIONSHIPS

Several sessions at the conference were devoted to purely political questions, such as the rearmament of Germany. At another session, the delegates agreed that the executive council should continue to work for the ultimate amalgamation of all engineering unions into one unit.

A demand that the union should withdraw from the Confederation was rejected by a large majority and a request that the National Union of General and Municipal Workers should be expelled from the Confederation was disposed of by proceeding to the "next business."

On May 6, a number of matters were discussed which had for their aim the improvement of conditions for engineering employees, but the resolutions passed were, in the main, somewhat unrealistic.

It was decided unanimously that the Government should be pressed to reduce the "intolerably high" cost of living, by reducing profits, limiting dividends, restoring food subsidies in full, and abolishing price-control rings. Another resolution, passed unanimously, asked for the introduction of a working week of 40 hours, against the existing week of 44 hours, without the loss of pay.

Approval was given to a resolution urging that the rates of women employees should be raised to the level of those of adult unskilled men.

STRIKE OVER LODGING TURNS

An unofficial strike against the introduction of new lodging turns, spells of duty on which engine crews are required to spend a night away from home, has developed on the Western Region of British Railways.

The trouble started at Newton Abbot on May 16, where most of the 350 railwaymen employed ceased work at midnight. Some 800 footplate men at Paddington and about 1,000 at Bristol decided to join in the stoppage as from 10 p.m. on Monday.

The strike was condemned by Mr. J. C. Baty, the general secretary of the Associated Society of Locomotive Engineers and Firemen. He said that, in accordance with the declared policy of the unions and British Railways, the new lodging turns had been agreed to by both sides.

NOTICES OF MEETINGS

Chemical Society

LONDON
Hudson Memorial Lecture, by Professor E. L. Hirst. Thurs., June 3, 7.30 p.m.

Institute of Fuel

BIRMINGHAM
Annual General Meeting. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham, 3. Thurs., May 27, 6 p.m.

Institute of Metals

LONDON
"Lattice Defects and Energy Stored in Deformed Metals," by Dr. W. Boas. Thurs., May 27, 5.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Application of Plastics in Chemical Engineering." Discussion. Midlands Graduates' and Students' Section. Chemical Engineering Department, Birmingham University, Edgbaston, Birmingham. Wed., May 26, 11 a.m.

Institution of Civil Engineers

LONDON
"Owen Falls, Uganda Hydro-Electric Development: General Aspects," by Sir Charles Westlake, T. A. L. Paton and R. W. Mountain. Joint Meeting with the Institution of Electrical Engineers. Tues., May 25, 5.30 p.m.
"Owen Falls: Constructional Problems," by D. P. Bertlin and Henry Olivier. With a note on "Model Tests," by Professor C. M. White. Supplementary Meeting. Wed., May 26, 5.30 p.m.
"Development and Utilisation of Hydro-Electric Power in Uganda," by Sir Charles Westlake, J. M. Stock and J. C. Lithgow. Joint Meeting with Institution of Electrical Engineers. At the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Thurs., May 27, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"Owen Falls, Uganda Hydro-Electric Development: General Aspects," by Sir Charles Westlake, T. A. L. Paton and R. W. Mountain. Joint Meeting with the Institution of Civil Engineers. At the Institution of Civil Engineers, Great George-street, S.W.1. Tues., May 25, 5.30 p.m.
"Electrical Power Demand and Supply in the United States and the Role of Research in the Quarter Century Ahead," by Philip Sporn. Supply Section Annual Lecture. Wed., May 26, 5.30 p.m.
"Development and Utilisation of Hydro-Electric Power in Uganda," by Sir Charles Westlake, J. M. Stock and J. C. Lithgow. Joint Meeting with the Institution of Civil Engineers. Thurs., May 27, 5.30 p.m.

Institution of Mining and Metallurgy

LONDON
Annual General Meeting, 4 p.m. (Open to members and non-corporate members of the Institution only.) Presidential Address by Brigadier R. S. G. Stokes, 5.15 p.m. (Open to members and visitors.) Geological Society's Apartments, Burlington House, Piccadilly, W.1. Thurs., May 27.

Institution of Production Engineers

SHREWSBURY
"Cutting Tools: Their Development and Application," by W. Castledine. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed. May 26, 7.30 p.m.

Institution of Structural Engineers

LONDON
Annual General Meeting. Thurs., May 27, 6 p.m.

Presentation of Technical Information Discussion Group

LONDON
"Some Historical Aspects of the Presentation of Scientific Information," by F. Greenaway. Tues., May 25, 6 p.m.

Royal Institution

LONDON
"Science and Man's Unfolding View of Himself," by Dr. Arthur H. Compton. Fri., June 4, 9 p.m.

The Royal Society

LONDON
"Soil Metabolism," by J. H. Quastel. Leeuwenhoek Lecture. Fri., May 28, 4.30 p.m. (Postponed from May 6.)

Society of Instrument Technology

LONDON
Annual General Meeting. Mansion House, 26 Portland-place, W.1. Tues., May 25, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. (VICtoria 6161.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Mining and Metallurgy, Salisbury House, Finsbury-circus, London, E.C.2. (MONarch 2096.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Presentation of Technical Information Discussion Group, Department of Electrical Engineering, University College London, Gower-street, W.C.1.
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.